REMARKS - General

The drawings objections are noted and are corrected with new drawings submitted herewith.

Also Applicant has rewritten all claims to define the elected invention more particularly and distinctly so as to overcome the technical rejections and define the invention patentably over the prior art.

1. This Amendment D is in response to the Office Action mailed September 10, 2003.

The Objection to the Drawings Under 37 CFR 1.83(a)

2. The drawings objections are noted and are corrected with new drawings submitted herewith.

2a. New drawings Fig. 26 shows the feature of "method of determining whether an asynchronous process should or should not be converted into a new periodic process, by calculating whether a ratio of processing capacity of the processor which is required to be reserved for the new periodic process, to a processor capacity that is required for the asynchronous process if left unconverted, exceeds a predetermined threshold value."

2b. New drawing Fig. 25A, Fig. 25B shows the feature of "a permitted range of offset of each new periodic process being a subinterval of an interval or a full interval that begins at the earliest time that the corresponding being converted asynchronous process can make a request for execution, and ends at a time equal to the sum of the earliest time that said being converted asynchronous process can make a request for execution plus the period length of the new periodic process minus one time unit."

2c. New drawings Fig. 27A, Fig. 27B shows the feature of "comprising during run-time, detecting, in a case in which no asynchronous process or periodic process that has started is to be immediately put into execution, conditions of whether there exists an execution of a first periodic process that is ready for execution and has not completed execution, and there does not exist any other execution of some second periodic process that has not yet completed, such that execution of the second periodic process is ordered before execution of the first periodic process in the pre-run-time schedule, and the time slot of the first periodic process is not nested within the time slot of the second periodic process in the pre-run-time schedule, and there does not exist any other execution of some third periodic process that is ready and has not completed execution, such that execution of the third periodic process is nested within the time slot of the first periodic process in the pre-run-time schedule, and beginning execution of the first periodic process immediately in the event said conditions are true."

Applicant hereby declares that the new drawings Fig. 25B, 26, 27A, 27B include no new matter.

Applicant submits that the drawings now comply with 37 CFR 1.83(a) and therefore requests withdrawal of this objection.

The Objection to the Claims Because of Informalities

3. The last O.A. objected to claims 86-88 and 90 because of the spelling error: "processers" should be spelled "processors". Applicant has cancelled claims 86-88 as Applicant considers them to be redundant over other rewritten claims.

4. The last O.A. objected to claim 93 because it was said that "some" should be changed to "a". Applicant has rewritten claim 93 as new claim 139 in which "some" has been changed to "a".

Accordingly Applicant submits that claim 139 is now in proper form and therefore requests withdrawal of this objection.

The Claims Rejection Under 35 USC § 112

5. The last O.A. rejected claim 59 under § 112, since it was said that there was insufficient antecedent basis for the limitation "the step of converting at least one asynchronous process" in the first two lines of the claim. Applicant has cancelled claims 59 as Applicant considers it to be redundant over other rewritten claims.

6. The last O.A. rejected claims 64-65, 74-75, 83-84, 91, 94-95, 99-103, 106, and 112 under § 112, since it was said that the above claims were indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention, since it was said that the term "latitude" is indefinite.

Claims 64-65, 75, 83-84, 91, 94-95, 99-103, and 112 have been replaced with substitute new claims 119-120, 124, 134-135, 138, 140-141, 145-149, and 150, respectively. Applicant has cancelled claim 106 as Applicant considers it to be redundant over other rewritten claims.

Applicant requests reconsideration and withdrawal of this objection since the present specification clearly defines the meaning of the term "latitude", and clearly teaches what specific values one should assign to it, and how to use it in the practice of the invention.

First, paragraph [0127] of the specification teaches that, *"The `latitude' of a process x, denoted by L_x, is a user defined measure of the latitude in meeting process x's deadline."*

Second, paragraph [0128] of the specification teaches that, *"For exemplary purposes, in all the examples given in the description of the present invention, we will assume that for each process x, L_x is set to the following value:*

- *for each periodic process p_i, $L_{pi} = d_{pi} - r_{pi}$;*
- *for each asynchronous process a_i, $L_{ai} = d_{ai}$;*

..."

(d_{pi}, r_{pi}, d_{ai} above are the deadline and release time of a periodic process p_i, the deadline of an asynchronous process a_i, respectively, as defined in paragraphs [0114] and [0117] of the specification.)

Paragraph [0129] of the specification teaches another example of specific values that one can assign to it, *"... for each P-h-k process or P-s-k process p_i, instead of defining $L_{pi} = d_{pi} - r_{pi}$, $L_{pi} = d_{pi}$ could be defined, or any other criteria for defining L_{pi} could be used."*

Third, whenever the term latitude is used in the claims 119-120, 124, 134-135, 138, 140-141, 145-149, and 150, corresponding use of the symbol form of latitude L_{pi}, L_{ai}, etc , is shown in specific paragraphs of the specification related to the claim. For example, claim 119 cites, *"...sufficient time capacity for execution of asynchronous processes that have less latitude than considered ones of periodic processes in meeting their respective deadlines."* Paragraphs [0145]-[0148] of the specification teaches this in detail, *"...Above, for each process p_i in S_P (the original set of P-h-k processes) or in S_P (the new periodic processes converted from A-h-k-p processes), for every possible occurrence of any A-h-k-a process a_j between r_{pi} and d_{pi}, if $L_{aj} \leq L_{pi}$ then a_j's computation time is added to p_i's computation time."*

Accordingly Applicant submits that the present specification clearly defines the meaning of the term "latitude", and clearly teaches what specific values one should assign to it, and how to use it in the practice of the invention; thus Applicant submits that the claims 119-120, 124, 134-135, 138, 140-141, 145-149, and 150 do comply with § 112 and therefore requests withdrawal of this objection.

7. The last O.A. rejected claim 63 under § 112, since it was said that the above claims were indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention, since it was said that the term "satisfied" is indefinite.

Claim 63 has been rewritten as new claim 118. Applicant submits that claim 118 now does comply with § 112 and therefore requests withdrawal of this objection.

8. The last O.A. rejected claims 62-63, 78-80, 104, and 110-111 under § 112, since it was said that the above claims were incomplete for omitting essential structural cooperative relationships. The last O.A. said that it was not clear if "relations" in claims 62-63, 78-80, 104, and 110-111 refers to "exclusion relations" or "relations comprising worst-case computation time."

Claims 62-63, and 78-80 have been rewritten as new claims 118, and 127-130 respectively. Applicant has cancelled claims 104, and 110-111 as Applicant considers them to be redundant over other rewritten claims. Claim 58 has been rewritten as new claim 115 in which "predetermined constraints" comprises "exclusion relations". Claims 118, and 127-130 now refer to "said predetermined constraints", which comprises the "exclusion relations" referred to in claim 115.

Applicant submits that the claims 118, and 127-130 now do comply with § 112 and therefore requests withdrawal of this objection.

9. The last O.A. rejected claims 62-63, and 78-80 under § 112, since it was said that the above claims were indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention, since it was said that the term "relations" is indefinite.

Claims 62-63, 78-80, 104, and 110-111 have been rewritten as new claims 118, and 127-130, respectively. Applicant has cancelled claims 104, and 110-111 as Applicant considers them to be redundant over other rewritten claims. Claim 58 has been rewritten as new claim 115 in which "predetermined constraints" comprises "exclusion relations". Claims 118, and 127-130 now refer to "said predetermined constraints", which comprises the "exclusion relations" referred to in claim 115.

Applicant submits that the claims 118, and 127-130 now do comply with § 112 and therefore requests withdrawal of this objection.

The Claims Rejection Under 35 USC § 102

10. The Rejection Of Claim 112 Under 35 USC § 102 On Dave (US 6,178,542 B1) Is Overcome

11. The last O.A. rejected independent claim 112 on Dave. Claim 112 has been rewritten as new claim 150 to define patentably over Dave and any combination thereof. Applicant requests reconsideration of this rejection, as now applicable to claim 150, for the following reasons:

11.1. Dave does not show the feature of satisfying constraints comprising exclusion relations and therefore does not provide the capability to prevent errors caused by more than one periodic process or asynchronous process simultaneously accessing shared resources such as data while maximizing the system's flexibility in meeting deadline constraints

Claim 150 clearly distinguishes over Dave since it recites

"including satisfaction of predetermined constraints comprising

...

(5) exclusion relations for periodic and asynchronous processes wherein each exclusion relation being defined between a pair of processes comprising a first process and a second process, said first process being either a periodic process or an asynchronous process and said second process being either a periodic process or an asynchronous process, said first process excludes said second process, no execution of said second process being allowed to occur between the time that said first process starts its execution and the time that said first process completes its computation,"

Dave does not show the feature of satisfying predetermined constraints comprising "*exclusion relations for periodic and asynchronous processes wherein each exclusion relation being defined between a pair of processes comprising a first process and a second process, said first process being either a periodic process or an asynchronous process and said second process being either a periodic process or an asynchronous process, said first process excludes said second process, no execution of said second process being allowed to occur between the time that said first process starts its execution and the time that said first process completes its computation,*" and therefore does not provide the capability to prevent errors caused by more than one process simultaneously accessing shared resources such as data while maximizing the system's flexibility in meeting deadline constraints, while the processes can be either (i) asynchronous processes that are not converted into new periodic processes and hence are not mapped into time slots in the pre-run-time schedule, (ii) asynchronous processes that are converted into new periodic processes and hence are mapped into time slots in the pre-run-time schedule, (iii) periodic processes that are mapped into time slots in the pre-run-time schedule.

(11.1.1.) Dave's "exclusion vector" ("*This specifies which pairs of tasks cannot co-exist on the same PE (such pairs may create processing bottlenecks)", Dave, col. 6, lines 13-15)* does not show the feature satisfying predetermined constraints comprising exclusion relations hence it is incapable of preventing overlapping in time of the executions of a selected pair of processes. Dave's exclusion vector does not provide the capability to prevent data inconsistencies caused by more than one process simultaneously accessing shared data, because even if a pair of tasks do not coexist on the same PE, they can still simultaneously access shared data and cause data inconsistencies when multiple processors share memory.

(11.1.2) Dave's combination of preemptive and nonpreemptive processing (*"The algorithm employs a combination of both preemptive and nonpreemptive scheduling. Preemptive scheduling is used in restricted scenarios to minimize scheduling*

complexity." Dave, col.10, lines 1-4). does not show the feature of satisfying predetermined constraints comprising exclusion relations.

(11.1.2a) Nonpreemptive in general does not provide the capability to prevent errors caused by more than one process simultaneously accessing shared resources such as data when the processes may execute on different processors that share memory, because a pair of tasks that do not coexist on the same PE can still simultaneously access shared data, even if both tasks are executed nonpreemptively.

(11.1.2b) Dave's combination of preemptive and nonpreemptive processing is based on a single parameter called "preemption overhead" *("for task preemption, the algorithm takes into consideration the operating system overheads such as interrupt overhead, context-switch, remote procedure call (RPC) etc. through a parameter called preemption overhead." Dave, col. 10, lines 5-8).* It is not defined on pairs of tasks, thus does not provide the capability to select precisely which pairs of process' executions should not overlap in time when they access shared data. For this reason Dave's combination of preemptive and nonpreemptive processing does NOT offer the same system flexibility in meeting deadline constraints that Applicant's invention as defined by claim 150 provides while Dave also fails to provide the capability to prevent errors caused by more than one process simultaneously accessing shared resources such as data when the processes may execute on different processors that share memory.

(11.1.2c) Dave's combination of preemptive and nonpreemptive processing is incapable of handling processes that can be either (i) asynchronous processes that are not converted into new periodic processes and hence are not mapped into time slots in the pre-run-time schedule, or (ii) asynchronous processes that are converted into new periodic processes and hence are mapped into time slots in the pre-run-time schedule, or (iii) periodic processes that are mapped into time slots in the pre-run-time schedule. Dave does not show any feature related to "*execution of asynchronous processes that are not converted to new periodic processes and hence not mapped to time slots in the pre-run-time schedule in a manner similar to mapping of other periodic processes.*" Dave maps <u>every</u>

aperiodic task to specific time slots in the schedule before run-time. *("The algorithm positions execution time slots for aperiodic task graphs throughout the hyperperiod," Dave, col. 7, lines 42-43).*

11.2. Dave does not show the feature of scheduling, between the beginning time and end time of each of the time slots in the pre-run-time schedule reserved for execution of a corresponding periodic process, time capacity sufficient to complete execution of said corresponding periodic process and additional time capacity sufficient to complete execution of asynchronous processes that are not converted to new periodic processes and hence not mapped to time slots in the pre-run-time schedule in a manner similar to mapping of other periodic processes and have less latitude than said corresponding periodic process in meeting their respective deadlines.

Claim 150 clearly distinguishes over Dave since it recites

> *"including scheduling, between the beginning time and end time of each of the time slots in the pre-run-time schedule reserved for execution of a corresponding periodic process, time capacity sufficient to complete execution of said corresponding periodic process and additional time capacity sufficient to complete execution of asynchronous processes that are not converted to new periodic processes and hence not mapped to time slots in the pre-run-time schedule in a manner similar to mapping of other periodic processes and have less latitude than said corresponding periodic process in meeting their respective deadlines."*

The last O.A. cited as reference prior patent 6,178,542 B1 to Dave *("For each aperiodic task, as explained before, the algorithm positions the execution slots throughout the hyperperiod after scheduling the first execution slot. If the execution slot cannot be allocated at the required instant, the algorithm schedules its at the earliest possible time and repositions the remaining slots to ensure that the deadlines are always met." Dave,*

col. 12, lines 20-26). Applicant submits that this is a misunderstood reference, as the reference clearly does not teach what the O.A. relies upon it as supposedly teaching.

The reference cited by the O.A. clearly does not show the feature of *"including scheduling, between the beginning time and end time of each of the time slots in the pre-run-time schedule reserved for execution of a corresponding periodic process, time capacity sufficient to complete execution of said corresponding periodic process and additional time capacity sufficient to complete execution of asynchronous processes that are not converted to new periodic processes and hence not mapped to time slots in the pre-run-time schedule in a manner similar to mapping of other periodic processes and have less latitude than said corresponding periodic process in meeting their respective deadlines"* :

11.2.1. Dave does not show any feature related to "*execution of asynchronous processes that are not converted to new periodic processes and hence not mapped to time slots in the pre-run-time schedule in a manner similar to mapping of other periodic processes."* Dave maps every aperiodic task to specific time slots in the schedule before run-time. *("The algorithm positions execution time slots for aperiodic task graphs throughout the hyperperiod," Dave, col. 7, lines 42-43).*

11.2.2. In Dave, after the arrival of an aperiodic task, that aperiodic task can only be executed in the specific time slots that were previously allocated to it before run-time. This is illustrated in Dave Fig. 2A and Fig. 2B *("Allocation of these two slots* ({2,4} and {6,8} in Fig. 2B) *in the hyperperiod for t2 guarantees that the deadline of t2 is always met ... If t2 arrives before or at instant 2, it will be served by slot {2,4}. If it arrives after instant 2 and before or at instant 6, it will be served by slot {6,8}. Similarly if it arrives after instant 6 and before or at instant 12, it will be served by the first slot of the next hyperperiod, and so on. Dave, col. 9, lines 7-14.)*

11.3. Dave does not show the feature of during run-time, scheduling of asynchronous processes that are not mapped to time slots combined with scheduling of periodic processes that are mapped to time slots

Claim 150 clearly distinguishes over Dave since it recites:

> *"during run-time using the information in the pre-run-time schedule, including the positions of the beginning time and end time of the time slots of the periodic processes, to schedule the process executions, including allowing executions of asynchronous processes that have not been mapped to time slots in the pre-run-time schedule to be completed within any time slot of a periodic process that has greater latitude in meeting its deadline, such that said predetermined constraints will be satisfied,"*

As Applicant has discussed above, Dave does not show the feature of "*including allowing executions of asynchronous processes that have not been mapped to time slots in the pre-run-time schedule to be completed within any time slot of a periodic process that has greater latitude in meeting its deadline, such that said predetermined constraints will be satisfied,*" Dave maps every aperiodic task to specific time slots in the schedule before run-time. *("The algorithm positions execution time slots for aperiodic task graphs throughout the hyperperiod," Dave, col. 7, lines 42-43).*

11.4. The Novel Features Of Claim 150 Produce New And Unexpected Results And Hence Are Unobvious And Patentable Over Dave Under § 102 and § 103

Claim 150 provides the following combination of features that have never before been provided simultaneously:

(1) Applicant's invention as defined by claim 150 provides the capability to enforce exclusion relations on pairs of processes that can be either (i) asynchronous processes that are not converted into new periodic processes and hence are not mapped into time slots in the pre-run-time schedule, or (ii) asynchronous processes that are converted into new periodic processes and hence are mapped

into time slots in the pre-run-time schedule, or (iii) periodic processes that are mapped into time slots in the pre-run-time schedule, thus providing the capability to prevent errors caused by more than one process simultaneously accessing shared resources such as data in systems of one or more processors while also providing the capability to select precisely which pairs of process' executions should not overlap in time when they access shared data thus maximizing the system's flexibility in meeting deadline constraints.

Dave does not provide this feature.

(2) Applicant's invention as defined by claim 150 simultaneously provides the capability to allow asynchronous processes with very short deadlines, to remain asynchronous and to not be converted to new periodic processes and hence not be allocated specific time slots in the pre-run-time schedule in order to make the most efficient use of processor capacity in a system where all periodic processes are scheduled in a pre-run-time schedule. In Applicant's invention, such asynchronous processes are allowed to execute at run-time within any time slot of a periodic process that has a longer deadline so that such asynchronous with very short deadlines have a much higher chance of meeting their deadlines. In Applicant's invention, this is made possible in part by scheduling additional time for such asynchronous processes in the time slots of periodic processes that have longer deadlines in the pre-run-time schedule.

Dave does not show this feature.

(3) Applicant's invention as defined by claim 150 provides the above combination of features, while providing the capability to handle processes that can be either (i) asynchronous processes that are not converted into new periodic processes and hence are not mapped into time slots in the pre-run-time schedule, or (ii) asynchronous processes that are converted into new periodic processes and hence are mapped into time slots in the pre-run-time schedule, or (iii) periodic processes that are mapped into time slots in the pre-run-time schedule, thus obtaining the advantages of pre-run-time scheduling including ability to use the information in the pre-run-time schedule to achieve greater predictability, ability to handle complex constraints, lower run-time overhead, and in general greatly increase the

efficiency of scheduling; and the advantages of run-time scheduling including ability to handle asynchronous processes with very short deadlines that cannot be converted into periodic processes or will waste too much processor capacity if converted into periodic processes, while providing a guarantee that all the constraints, including hard deadlines, will be satisfied before run-time.
Dave does not show this combination of features.

A. Applicant's invention as defined by claim 150 achieves **unexpected results**: A system with all the above important features combined together, has never been realized before. The combination of results achieved by Applicant's invention as defined by claim 150 are new and vastly superior compared to that of Dave, or any combination thereof.

B. Applicant's invention as defined by claim 150 is classified in a **crowded art** (the prior art patent Dave cited by the O.A. states that, *"There is a vast amount of literature in the area of scheduling of soft and hard aperiodic tasks", Dave, col. 2, lines 47-48*); therefore, even a small step forward should be regarded as significant.

Applicant therefore submits that claim 150 is patentable under § 102 and § 103 and should be allowed, since they produce new and unexpected results over Dave , or any combination thereof.

The Claims Rejection Under 35 USC § 103

12. The Rejection Of Claim 58 Under 35 USC § 103 On Dave (US 6,178,542 B1) and Dave2 (US 6,086,628) Is Overcome

13. The last O.A. rejected independent claim 58 on Dave and Dave2. Claim 58 has been rewritten as new claim 116 to define patentably over Dave and Dave2 and any combination thereof. Applicant requests reconsideration of this rejection, as now applicable to claim 116, for the following reasons:

13.1. Neither Dave nor Dave2 show the feature of satisfying constraints comprising exclusion relations and therefore does not provide the capability to prevent errors caused by more than one periodic process or asynchronous process simultaneously accessing shared resources such as data while maximizing the system's flexibility in meeting deadline constraints.

(Discussion on Dave's lack of this feature is provided in item 11.1. above and is equally applicable to Dave and Dave2, and is hereby included here by reference.)

Claim 116 clearly distinguishes over Dave and Dave2 since it recites

"including satisfaction of predetermined constraints comprising

...

(4) exclusion relations for periodic and asynchronous processes wherein each exclusion relation being defined between a pair of processes comprising a first process and a second process, said first process being either a periodic process or an asynchronous process and said second process being either a periodic process or an asynchronous process, said first process excludes said second process, no execution of said second process being allowed to occur between the time that said first process starts its execution and the time that said first process completes its computation,"

Neither Dave nor Dave2 show the feature of satisfying predetermined constraints comprising "*exclusion relations for periodic and asynchronous processes wherein each exclusion relation being defined between a pair of processes comprising a first process and a second process, said first process being either a periodic process or an asynchronous process and said second process being either a periodic process or an asynchronous process, said first process excludes said second process, no execution of said second process being allowed to occur between the time that said first process starts*

its execution and the time that said first process completes its computation," and therefore does not provide the capability to prevent errors caused by more than one process simultaneously accessing shared resources such as data while maximizing the system's flexibility in meeting deadline constraints, while the processes can be either (i) asynchronous processes that are not converted into new periodic processes and hence are not mapped into time slots in the pre-run-time schedule, or (ii) asynchronous processes that are converted into new periodic processes and hence are mapped into time slots in the pre-run-time schedule, or (iii) periodic processes that are mapped into time slots in the pre-run-time schedule.

The last O.A. citation of the features of Dave *("mapping of tasks to processing elements", "finish time", "constraints", col. 1, lines 50-67, and "co-simulation", col. 2, lines 17-43, and "periodic task graphs", "deadlines", col. 4, lines 53-67, and "finish-time estimation step is enhanced by employing a deadline-based scheduling technique", col. 5, lines 1-7, "worst-case execution times", "mapping tasks", col. 5, lines 25-46, "start time", "period", "deadline", col. 5, lines 53-67, "execution time slots", col. 7, lines 40-54),* does not show the Applicant's invention feature of exclusion constraints as cited above.

(Discussion on Dave's lack of this feature is provided in item 11.1. above and is equally applicable to Dave and Dave2, and is hereby included here by reference.)

13.2. Neither Dave nor Dave2 show the feature of permitted range of offset constraints for periodic processes

Claim 116 clearly distinguishes over Dave and Dave2 since it recites

"including satisfaction of predetermined constraints comprising

...

(4) *permitted range of offset constraints for periodic processes wherein a permitted range of offset of a periodic process comprising an interval that begins at a lower bound value and ends at an upper bound value which may be equal to*

the lower bound value, the duration of the time interval between the beginning of the first period of said periodic process and time zero must be greater than or equal to said lower bound value and less than or equal to said upper bound value, n,"

Neither Dave nor Dave2 show the feature of satisfying predetermined constraints comprising "*permitted range of offset constraints for periodic processes wherein a permitted range of offset of a periodic process comprising an interval that begins at a lower bound value and ends at an upper bound value which may be equal to the lower bound value, the duration of the time interval between the beginning of the first period of said periodic process and time zero must be greater than or equal to said lower bound value and less than or equal to said upper bound value, n,"*

The last O.A. cited the following features of Dave2 (*"An association array has an entry for each task of each copy of the task graph and contains information such as: 1) the PE to which it is allocated, 2) its priority level, 3) its deadline, 4) its best-case projected finish time (PFT), and its 5) its worst-case PFT. The deadline of the nth instance of a task is offset by (n-1) multiplied by its period from the deadline in the original task. The association array not only eliminates the need to replicate the task graphs, but it also allows allocation of different task graphs copies to different PEs, if desirable to derive en efficient architecture. This array also supports pipelining of task graphs, which is explained later in this specification.", col. 10, lines 1-12*). The last O.A. said that the above reference teaches using any offset value in a permitted range of offsets. Applicant submits that the above reference is a misunderstood reference, as the reference does not teach what the O.A. relies upon it as supposedly teaching.

Note that:

13.2.1. The term "offset" in the reference above refers to the duration of the time interval between the deadline of the nth instance in the nth period of the same task and the deadline of the first instance in the first period of the task.

13.2.2. In contrast, in Applicant's invention as defined by claim 116, the term "offset"

refers to *"the duration of the time interval between the beginning of the first period of said periodic process and time zero" (Constraint (4) of Applicant's claim 116).*

13.2.3. The meaning of the term "offset" in Dave2 is clearly completely different from the meaning of the term "offset" in Applicant's invention as defined by claim 116. Thus the use of the term "offset" in Dave2 does not provide evidence that Dave2 shows the feature of "permitted range of offsets for periodic processes" in claim 116.

13.4. The Novel Features Of Claim 116 Produce New And Unexpected Results And Hence Are Unobvious And Patentable Over Dave and Dave 2 Under § 103

Claim 116 provides the following combination of features that have never before been provided simultaneously:

(1) Applicant's invention as defined by claim 116 provides the capability to enforce exclusion relations on pairs of processes that can be either (i) asynchronous processes that are not converted into new periodic processes and hence are not mapped into time slots in the pre-run-time schedule, or (ii) asynchronous processes that are converted into new periodic processes and hence are mapped into time slots in the pre-run-time schedule, or (iii) periodic processes that are mapped into time slots in the pre-run-time schedule, thus providing the capability to prevent errors caused by more than one process simultaneously accessing shared resources such as data in systems of one or more processors while also providing the capability to select precisely which pairs of process' executions should not overlap in time when they access shared data thus maximizing the system's flexibility in meeting deadline constraints.

Neither Dave nor Dave2 show this feature.

(2) Applicant's invention as defined by claim 116 simultaneously provides the capability to increase the flexibility of meeting deadline constraints when there is flexibility in assigning an offset value for a periodic process.

Neither Dave nor Dave2 show this feature.

(3) Applicant's invention as defined by claim 116 provides the above combination of features, while providing the capability to handle processes that can be either (i) asynchronous processes that are not converted into new periodic processes and hence are not mapped into time slots in the pre-run-time schedule, or (ii) asynchronous processes that are converted into new periodic processes and hence are mapped into time slots in the pre-run-time schedule, or (iii) periodic processes that are mapped into time slots in the pre-run-time schedule, thus obtaining the advantages of pre-run-time scheduling including ability to use the information in the pre-run-time schedule to achieve greater predictability, ability to handle complex constraints, lower run-time overhead, and in general greatly increase the efficiency of scheduling; and the advantages of run-time scheduling including ability to handle asynchronous processes with very short deadlines that cannot be converted into periodic processes or will waste too much processor capacity if converted into periodic processes, while providing a guarantee that all the constraints, including hard deadlines, will be satisfied before run-time.
Neither Dave nor Dave2 do not show this combination of features.

A. Applicant's invention achieves **unexpected results**: A system with all the above important features combined together, has never been realized before. The combination of results achieved by Applicant's invention are new and vastly superior compared to that of Dave and Dave2, or any combination thereof.

B. Applicant's invention is classified in a **crowded art** (a prior art patent cited by the O.A. states that, *"There is a vast amount of literature in the area of scheduling of soft and hard aperiodic tasks", Dave, col. 2, lines 47-48*); therefore, even a small step forward should be regarded as significant.

Applicant therefore submits that claim 116 is patentable under § 102 and § 103 and should be allowed, since they produce new and unexpected results over Dave and Dave2, or any combination thereof.

14. The Rejection Of Claims 59-65, 68, 75-76, 78-79, 81, 83-85, 89, 91, 95, 86-88, 90, 92, 94, 97-99, 103-110, 113-114 Under 35 USC § 103 On Dave (US 6,178,542 B1), Dave2 (US 6,086,628), and Lindsley (US 6,430,593 B1)

15. The Rejection Of Claim 59 Under 35 USC § 103 On Dave (US 6,178,542 B1), Dave2 (US 6,086,628), and Lindsley (US 6,430,593 B1) Is Overcome

The last O.A. rejected dependent claim 59 on Dave, Dave2, and Lindsley. Claim 59 has been rewritten as new independent claim 115 to define patentably over Dave, Dave2, and Lindsley and any combination thereof. Applicant requests reconsideration of this rejection, as now applicable to claim 115, for the following reasons:

(1) There is no justification, in Dave, Dave2, and Lindsley, or in any other prior art separate from Applicant's disclosure, which suggests that these references be combined, much less combined in the manner proposed.
(2) The proposed combination would not be physically possible or operative.
(3) Even if Dave, Dave2, and Lindsley were to be combined in the manner proposed, the proposed combination would not show all of the novel physical features of claim 115.
(4) The novel features of claim 115 produce new and unexpected results and hence are unobvious and patentable over these references.

15.1. Dave, Dave2, and Lindsley Do Not Contain Any Justification To Support Their Combination, Much Less In The Manner Proposed

With regard to the proposed combination of Dave, Dave2, and Lindsley, it is well known that in order for any prior-art references themselves to be validly combined for use in a prior-art § 103 rejection, *the references themselves* (or some other prior art) must suggest that they be combined. E.g., as was stated in In re Sernaker, 217 U.S.P.Q. 1, 6 (C.A.F.C. 1983):

"[P]rior art references in combination do not make an invention obvious unless something in the prior art references would suggest the advantage to be derived from combining their teachings."

That the suggestion to combine the references should not come from applicant was forcefully stated in Orthopedic Equipment Co. v. United States, 217 U.S.PQ. 193, 199 (CAFC 1983):

"It is wrong to use the patent in suit [here the patent application] as a guide through the maze of prior art references, combining the right references in the right way to achieve the result of the claims in suit [here the claims pending]. Monday morning quarterbacking is quite proper when resolving the question of nonobviousness in a court of law [here the PTO]."

As was further stated in Uniroyal, Inc. v. Rudkin-Wiley Corp., 5 U.S.P.Q.2d 1434 (C.A.F.C. 1988), "[w]here prior-art references require selective combination by the court to render obvious a subsequent invention, there must be some reason for the combination other than the hindsight gleaned from the invention itself. . . . *Something in the prior art must suggest the desirability and thus the obviousness of making the combination.*" [Emphasis supplied.]

In line with these decisions, the Board stated in Ex Parte Levengood, 28 U.S.P.Q.2d 1300 [P.T.O.B.A.&]. 1993):

"In order to establish a *prima facie* case of obviousness, it is necessary for the examiner to present evidence, preferably in the form of some teaching, suggestion, incentive or inference in the applied prior art, or in the form of generally available knowledge, that one having ordinary skill in the art *would have been led to* combine the relevant teachings of the applied references in the proposed manner to arrive at the claimed invention. . . . That which is within the capabilities of one skilled in the art is not synonymous with obviousness, ... That one can *reconstruct* and/or explain the theoretical mechanism of an invention by means of logic and sound scientific reasoning does not

afford the basis for an obviousness conclusion unless that logic and reasoning also supplies sufficient impetus to have led one of ordinary skill in the art to combine the teachings of the references to make the claimed invention. . . . Our reviewing courts have often advised the Patent and Trademark Office that it can satisfy the burden of establishing a *prima facie* case of obviousness only be showing some objective teaching in either the prior art, or knowledge generally available to one of ordinary skill in the art, that `would lead' that individual `to combine the relevant teachings of the references." ... Accordingly, an examiner cannot establish obviousness by locating references which describe various aspects of a patent application's invention without also providing evidence of the motivating force which would impel one skilled in the art to do what the patent applicant has done."

In the present case, there is no reason given in the last O.A. to support the proposed combination, other than the statement *"Referring to claim 59, Dave inherently teaches mapping onto timeslots but fails to explicitly teach a method as defined in claim 58, including the step of converting at least one asynchronous process to a corresponding new periodic process prior to the mapping step, and mapping the new periodic process in a manner similar to mapping of other periodic processes. It is common knowledge in the art of task management that converting an asynchronous process to a new periodic process (or a synchronous process) is known as synchronization. Lindsley teaches a real-time task scheduling system which synchronizes tasks/processes ("processes", synchronized", col. 2, lines 48-61, "asynchronous", col. 4, lines 19-23). It would have been obvious to one of ordinary skill in the art at the time the invention was made to include the feature of synchronization for the reason of increasing speed and efficiency because synchronization is necessary for parallel processing."*

However, the fact that the words "processes", "synchronized" (Lindsley, col. 2, lines 46-61), "asynchronous" (Lindsley, col. 4, lines 19-23) appear in the reference is not sufficient to gratuitously and selectively combine parts of one reference (Lindsley's task synchronization mechanism) with another reference in order to meet Applicant's novel claimed combination of features.

Note that:

15.1.1. The meaning of the term "synchronous" in Lindsley is inherently different from the meaning of "periodic" in Applicant's invention as defined by claim 115 as shown below:

15.1.1.(a) Lindsley uses the term "synchronous" when describing "synchronous task commands". *("The TSA accepts commands from tasks called `synchronous' task commands. These commands are synchronous from the point of view that the task may not issue another synchronous task command until the previous synchronous task command has been completed. It is allowable for the task to perform other activity after issuing a synchronous task command as long as the task verifies that the previous task has been completed prior to issuing another synchronous task command." Lindsley, col. 6, lines 47-55.)* It is clear that in Lindsley there is no periodic constraint on "synchronous" task commands, i.e., synchronous task commands are not constrained to execute strictly once in each fixed period of time.

15.1.1.(b) In contrast, in Applicant's invention as defined by claim 115, "a periodic process consists of a computation that is executed repeatedly, once in each fixed period of time. (Applicant's specification, paragraph [0113]). Applicant's definition of a periodic process, is adopted universally in the field of real-time computing and is clearly different from the meaning of "synchronous" as defined in Lindsley.

15.1.2. The meaning of the term "*synchronization*" in Lindsley is also inherently different from the meaning of "*converting an asynchronous process to a new periodic process*" in Applicant's invention as defined by claim 115 as shown below:

15.1.2.(a) In Lindsley, tasks are synchronized using "events" which are certainly NOT always periodic.*("Tasks are typically synchronized using "events". An event is used to indicate that an activity has taken place, such as data arrival, time-out, etc. Thus, an event may indicate execution of a task, an interrupt service routine or the like. Events are counted using semaphores. Semaphores synchronize the event producer and the event consumer ..." Lindsley, col. 2, lines 4-10.)*

("If a task that processes data buffers pends for the semaphore that represents data buffers, the task is synchronized to the data buffer generation. If data buffers are available, the semaphore count is greater than zero. Task pend requests on the semaphore allow the task to continue. If data buffers are not available, the semaphore count is less than or equal to zero, the task does not have data for processing and will block execution". Lindsley, col. 2, lines 52-61.)

15.1.2.(b) In contrast, in Applicant's invention as defined by claim 115, "*converting an asynchronous process to a new periodic process*" means converting a process that can make a request at random times, to a new process that will be executed once in each fixed period of time while satisfying all the original process' timing constraints.

The above evidence, clearly shows that the last O.A.'s reason for combining Dave, Dave2, and Lindsley to find obviousness of claim 115, i.e., *("It is common knowledge in the art of task management that converting an asynchronous process to a new periodic process (or a synchronous process) is known as synchronization,"* is totally unfounded.

Applicant therefore submits that combining Dave, Dave2, and Lindsley is not legally justified and is therefore improper. Thus Applicant submits that the rejection on these references is also improper and should be withdrawn.

Applicant respectfully requests, if the claims are again rejected upon any combination of references, that the Examiner include an explanation, in accordance with M.P.E.P. § 706.02, Ex parte Clapp, 27 U.S.P.Q. 972 (P.O.B.A. 1985), and Ex parte Levengood, supra, a "factual basis to support his conclusion that it would have been obvious" to make the combination,

15.2. Even if Dave, Dave2, and Lindsley Were To Be Combined In The Manner Proposed, The Proposed Combination Would Not Show All The Novel Features Of Claim 115.

However even if the combination of Dave, Dave2, and Lindsley were justified, claim 115 would still have novel and unobvious features over the proposed combination.

15.2.1. Neither Dave, nor Dave2, nor Lindsley, nor any possible combination thereof show the feature of automatically generating a pre-run-time schedule in which predetermined constraints comprising worst-case computation time, period, minimum time between two consecutive exclusion relations, deadline, permitted range of offset constraints, precedence relations are satisfied.

(Discussion on Dave's lack of ability to satisfy exclusion constraints is provided in item 11.1. above and is equally applicable to Dave and Dave2 and is hereby included here by reference.)

Claim 115 clearly distinguishes over Dave, Dave2 and Lindsley, or any possible combination thereof, since it recites

"*automatically generating a pre-run-time schedule comprising mapping from a set of periodic process executions to a sequence of time slots on one or more processor time axes, each of the time slots having a beginning time and an end time, reserving each one of the time slots for execution of one of the periodic processes, the positions of the end time and the beginning time of each of the time slots being such that execution of the periodic processes,*

including satisfaction of predetermined constraints comprising

(1) worst-case computation times for periodic processes and asynchronous processes,

(2) period for periodic processes,

(3) minimum time between two consecutive requests for asynchronous processes,

(4) deadline for periodic processes and asynchronous processes,

(5) permitted range of offset constraints for periodic processes wherein a permitted range of offset of a periodic process comprising an interval that

begins at a lower bound value and ends at an upper bound value which may be equal to the lower bound value, the duration of the time interval between the beginning of the first period of said periodic process and time zero must be greater than or equal to said lower bound value and less than or equal to said upper bound value,

(6) precedence relations for periodic processes wherein each precedence relation being defined between a pair of processes comprising a first process and a second process, both said first process and said second process being periodic processes, said first process precedes said second process, execution of said second process only allowed to start after said first process has completed its execution,

(7) exclusion relations for periodic and asynchronous processes wherein each exclusion relation being defined between a pair of processes comprising a first process and a second process, said first process being either a periodic process or an asynchronous process and said second process being either a periodic process or an asynchronous process, said first process excludes said second process, no execution of said second process being allowed to occur between the time that said first process starts its execution and the time that said first process completes its computation,

can be completed between the beginning time and end time of respective time slots, including the step of converting one or more asynchronous processes into corresponding new periodic processes prior to the mapping step, and mapping new periodic processes to time slots in a manner similar to mapping of other periodic processes, such that said predetermined constraints will be satisfied".

Neither Dave, nor Dave2, nor Lindsley, nor any possible combination thereof, show the feature of *automatically generating a pre-run-time schedule including satisfaction of predetermined constraints comprising*

"exclusion relations for periodic and asynchronous processes wherein each exclusion relation being defined between a pair of processes comprising a first process and a second process, said first process being either a periodic process or an asynchronous process and said second process being either a periodic process or an asynchronous process, said first process excludes said second process, no execution of said second process being allowed to occur between the time that said first process starts its execution and the time that said first process completes its computation".
(Discussion on Dave's lack of this feature is provided in item 11.1. above and is equally applicable to Dave and Dave2, and is hereby included here by reference.)

Note that Lindsley performs synchronization only at run-time, NOT before run-time, so it is not capable of satisfying any constraints before run-time, which Applicant's invention, as defined by claim 115 has shown.

15.2.2. Neither Dave, nor Dave2, nor Lindsley, nor any possible combination thereof show the feature of permitted range of offset constraints for periodic processes

Claim 115 clearly distinguishes over any combination of Dave, Dave2 and Lindsley since it recites

"including satisfaction of predetermined constraints comprising

...

(4) *permitted range of offset constraints for periodic processes wherein a permitted range of offset of a periodic process comprising an interval that begins at a lower bound value and ends at an upper bound value which may be equal to the lower bound value, the duration of the time interval between the beginning of the first period of said periodic process and time zero must be greater than or equal to said lower bound value and less than or equal to said upper bound value, n,"*

Dave, nor Dave2, nor Lindsley, nor any possible combination thereof show the feature of satisfying predetermined constraints comprising "*permitted range of offset constraints for periodic processes wherein a permitted range of offset of a periodic process comprising an interval that begins at a lower bound value and ends at an upper bound value which may be equal to the lower bound value, the duration of the time interval between the beginning of the first period of said periodic process and time zero must be greater than or equal to said lower bound value and less than or equal to said upper bound value, n,*"

15.3. The Suggested Combination Of Dave, Dave2, And Lindsley Would Not Be Physically Possible Or Operative.

There is plenty of unequivocal evidence that show that the suggested combination of Dave, Dave2, and Lindsley would not be physically possible or operative, here is just a few of them:

15.3.1. Lindsley describes a method which is totally void of any consideration of quantitative timing constraints.

Lindsley does not take into account:

(a) worst-case computation time values of asynchronous or periodic processes,
(b) deadline values of asynchronous or periodic processes,
(c) period values of periodic processes
(d) minimum time between two requests of asynchronous processes
(e) permitted range of offset values for periodic processes.

15.3.2. It is notoriously well-known, and common sense would also dictate that, if any single one of the above quantitative timing constraints is not taken into consideration, then there is absolutely no hope of satisfying the timing constraints.

15.3.3. The references of Dave and Dave2 do not contain any teaching, that suggests that their method could be physically combined with the teachings of Lindsley.

Neither does the reference of Lindsley contain any teaching, that suggests the teaching of Lindsley could be physically combined with the teachings of Dave and Dave2.

15.3.4. There is no evidence in the prior art that suggests that the references of Dave, Dave2, and Lindsley could be combined to produce an operative method.

15.3.5. Combining Dave, Dave2, and Lindsley will NOT produce an operative method that will cover all the features of claim 115. Lindsley does not show any feature that relate to time slots, and Lindsley does not concern itself with satisfying timing constraints, thus it NOT be able to schedule tasks that have been pre-allocated to time slots together with tasks that are not allocated to time slots, while simultaneously satisfying all the timing constraints.

15.3.6. As shown in item 15.1.1 above, Lindsley does not even consider periodic processes.

15.3.7. As shown in item 15.1.1 above, the last O.A.'s citation of Lindsley is a misunderstood reference. The reference does not teach what the last O.A. relies upon it as supposedly teaching. The main task feature of "synchronous" is not identical to "periodic" as the last O.A. assumed.

15.3.8. The reference of Lindsley relies on the use of general semaphores. It is notoriously well known that general semaphores are not suitable for use in systems with hard deadlines and may prevent the satisfaction of hard deadline constraints altogether. Here is just one simple example: general semaphores are subject to deadlock and various forms of starvation, and just detecting deadlocks alone is an NP-Hard problem, not to mention the total breakdown in any capability to meet any kind of timing constraints when a deadlock does occur. The

entire specification of Lindsley completely ignores this problem. As to be expected, the references of Dave and Dave2 also completely ignores this problem.

15.3.9. Even if Dave and Dave2 were operative when functioning alone, and even if it is structurally possible to combine them with Lindsley, the resulting method will be inoperative for the purpose of satisfying hard timing constraints at the very least because of the possibility of deadlock in Lindsley's method.

15.4. The Novel Features Of Claim 115 Produce New And Unexpected Results And Hence Are Unobvious And Patentable Over Any Possible Combination Of Dave, Dave 2 And Lindsley Under § 103

Claim 115 provides the following combination of features that have never before been provided simultaneously:

(1) Applicant's invention as defined by claim 115 provides the capability to enforce exclusion relations on pairs of processes that can be either (i) asynchronous processes that are not converted into new periodic processes and hence are not mapped into time slots in the pre-run-time schedule, or (ii) asynchronous processes that are converted into new periodic processes and hence are mapped into time slots in the pre-run-time schedule, or (iii) periodic processes that are mapped into time slots in the pre-run-time schedule, thus providing the capability to prevent errors caused by more than one process simultaneously accessing shared resources such as data in systems of one or more processors while also providing the capability to select precisely which pairs of process' executions should not overlap in time when they access shared data thus maximizing the system's flexibility in meeting deadline constraints.

Neither Dave, nor Dave 2, nor Lindsley show this feature.

(2) Applicant's invention as defined by claim 115 simultaneously provides the capability to increase the flexibility of meeting deadline constraints when there is flexibility in assigning an offset value for a periodic process.

Neither Dave, nor Dave 2, nor Lindsley show this feature.

(3) Applicant's invention as defined by claim 115 provides the above combination of features, while providing the capability to handle processes that can be either (i) asynchronous processes that are not converted into new periodic processes and hence are not mapped into time slots in the pre-run-time schedule, or (ii) asynchronous processes that are converted into new periodic processes and hence are mapped into time slots in the pre-run-time schedule, or (iii) periodic processes that are mapped into time slots in the pre-run-time schedule, thus obtaining the advantages of pre-run-time scheduling including ability to use the information in the pre-run-time schedule to achieve greater predictability, ability to handle complex constraints, lower run-time overhead, and in general greatly increase the efficiency of scheduling; and the advantages of run-time scheduling including ability to handle asynchronous processes with very short deadlines that cannot be converted into periodic processes or will waste too much processor capacity if converted into periodic processes, while providing a guarantee that all the constraints, including hard deadlines, will be satisfied before run-time.
Neither Dave, nor Dave 2, nor Lindsley show this combination of features.

A. Applicant's invention achieves **unexpected results**: A system with all the above important features combined together, has never been realized before. The combination of results achieved by Applicant's invention are new and vastly superior compared to that of Dave, Dave2, and Lindsley or any combination thereof.

B. Applicant's invention is classified in a **crowded art** (a prior art patent cited by the O.A. states that, *"There is a vast amount of literature in the area of scheduling of soft and hard aperiodic tasks", Dave, col. 2, lines 47-48*); therefore, even a small step forward should be regarded as significant.

Applicant therefore submits that claim 115 is patentable under § 102 and § 103 and should be allowed, since they produce new and unexpected results over Dave, Dave2, and Lindsley or any combination thereof.

The Dependent Claims 59-65, 68, 75-76, 78-79, 81, 83-85, 89, 91, 95, 86-88, 90, 92, 94, 97-99, 103-110, 113-114 Are A Fortiori Patentable Over Dave, Dave2, and Lindsley

New dependent claims 117-149, 152-153 incorporate the subject matter of claim 116, claim 115, and 160 and add additional subject matter which makes them a fortiori and independently patentable over these references.

16. The last O.A. rejected dependent claim 60 on Dave, Dave2, and Lindsley. Claim 60 has been cancelled since Applicant considers it to be redundant over the rewritten claims.

17. The last O.A. rejected dependent claim 61 on Dave, Dave2, and Lindsley. Claim 61 has been rewritten as new dependent claim 117 to define patentably over Dave, Dave2, and Lindsley and any combination thereof.
Applicant submits that claim 117 is independently patentable over Dave, Dave2, and Lindsley and any combination therefore for the same reasons as given in item 15 above.

Additional comments: The last O.A. said that "Lindsley teaches executing a set of non-converted asynchronous processes during run-time of the processor at times which do not interfere with executions of processes contained in the pre-run-time schedule." Applicant submits that the above statement is mistaken because Lindsley does not teach anything related to a pre-run-time schedule. In addition, any possible combination of Dave, Dave2, Lindsley will be inoperative for reasons detailed in item 15 above.

18. The last O.A. rejected dependent claim 62 on Dave, Dave2, and Lindsley. Claim 62 has been rewritten as new dependent claim 118 to define patentably over Dave, Dave2, and Lindsley and any combination thereof.
Applicant submits that claim 118 is independently patentable over Dave, Dave2, and Lindsley and any combination therefore for the same reasons as given in item 15 above.

Additional comments: The last O.A. said that "Dave in view of Lindsley teaches a method as defined in claim 58 including, following pre-run-time scheduling and during run-time of the processor, the step of scheduling executions of a specified set of periodic and asynchronous processes such that said predetermined constraints is satisfied . . . In addition, Dave teaches scheduling tasks to be executed (*"The next step is scheduling which determines the relative orderings of tasks/edges for execution... the algorithm employs a combination of both preemptive and non-preemptive static scheduling" col. 9, lines 65-67 through col. 10, lines 1-50*) Applicant submits that the above statement is mistaken because in the above citation of Dave, "scheduling" refers to scheduling of tasks before run-time. In addition, any possible combination of Dave, Dave2, and Lindsley will be inoperative for reasons detailed in item 15 above.

19. The last O.A. rejected dependent claim 63 on Dave, Dave2, and Lindsley. Claim 63 has been rewritten as new dependent claim 118 to define patentably over Dave, Dave2, and Lindsley and any combination thereof.
Applicant submits that claim 118 is independently patentable over Dave, Dave2, and Lindsley and any combination therefore for the same reasons as given in item 15 above.

Additional comments: The last O.A. said that "Dave in view of Lindsley teaches a method as defined in claim 58 including, following pre-run-time scheduling and during run-time of the processor, the step of scheduling executions of a specified set of periodic and asynchronous processes such that said predetermined constraints is satisfied . . . Dave in view of Lindsley fails to explicitly teach the specified constraints and relations will be satisfied. However, "Official Notice" is taken that both the concepts and advantages of providing that satisfying all constraints/relations is well known and

expected in the art. It would have been obvious to one of ordinary skill in the art at the time the invention was made to include satisfying all constraints/relations to the existing method for the reason of improving accuracy by making sure that no constraints/relations are missed."

Applicant respectfully disagrees with the above "Official Notice", and requests that documentary proof be provided, and the data be stated as specifically as possible, and the facts be supported, under M.P.E.P Section 2144.03 and 37 CFR 1.104(d)(2) for the "Office Notice" position that "it would have been obvious to one of ordinary skill in the art at the time the invention was made to include satisfying all constraints/relations to the existing method for the reason of improving accuracy by making sure that no constraints/relations are missed."

The reasons that Applicant disagrees with the above "Official Notice" are as follows:

1. Applicant has practiced the art of scheduling processes with hard-timing constraints for 20 years as a researcher and academic, and in Applicant's experience, being able to provide proof and guarantee before run-time that a scheduling method will satisfy all the specified constraints is the single most critical, most difficult, and most valuable feature to achieve in a safety-critical system with hard timing constraints.
2. In Applicant's experience, among the vast number of scheduling methods that have been published or patented, scheduling methods that can truly provide proof and guarantee before run-time that a scheduling method will satisfy all the specified constraints are very rare, and correspondingly very few inventors are able to make such a claim. This is especially true when the specified constraints include complex constraints such as exclusion relations, permitted range of offset, precedence, as defined in Applicant's invention.
3. It is Applicant's position that the capability to provide proof and guarantee before run-time that all the specified constraints will be satisfied should be one of the most important criteria in judging the patentability of a real-time scheduling method.

20. The last O.A. rejected dependent claim 64 on Dave, Dave2, and Lindsley. Claim 64 has been rewritten as new dependent claim 119 to define patentably over Dave, Dave2, and Lindsley and any combination thereof.
Applicant submits that claim 119 is independently patentable over Dave, Dave2, and Lindsley and any combination therefore for the same reasons as given in item 15 above.

Additional comments: The last O.A. said that "Dave in view of Lindsley teaches scheduling, within the pre-run-time schedule, a difference between the end time and the beginning time of each of said periodic time slots with sufficient time capacity for execution of asynchronous processes that have less latitude than considered ones of periodic processes in meeting their respective deadlines. In addition, Dave teaches that processes in the schedule fit into time slots *("For each aperiodic task, as explained before, the algorithm positions the execution slots throughout the hyperperiod after scheduling the first execution slot. If the execution slot cannot be allocated at the required instant, the algorithm schedules its at the earliest possible time and repositions the remaining slots to ensure that the deadlines are always met." Dave, col. 12, lines 20-26).* Applicant submits that this is a misunderstood reference, as the reference clearly does not teach what the O.A. relies upon it as supposedly teaching, that is, it does not teach the feature in claim 119. Applicant has discussed this in more detail in item 11.2.1. and 11.2.2. above.

21. The last O.A. rejected dependent claim 65 on Dave, Dave2, and Lindsley. Claim 65 has been rewritten as new dependent claim 120 to define patentably over Dave, Dave2, and Lindsley and any combination thereof.
Applicant submits that claim 120 is independently patentable over Dave, Dave2, and Lindsley and any combination therefore for the same reasons as given in items 15 and 20 above.

22. The last O.A. rejected dependent claim 75 on Dave, Dave2, and Lindsley. Claim 75 has been rewritten as new independent claim 124 to define patentably over Dave, Dave2, and Lindsley and any combination thereof.
Applicant submits that claim 124 is independently patentable over Dave, Dave2, and Lindsley and any combination therefore for the same reasons as given in items 15 and 20 above

23. The last O.A. rejected dependent claim 76 on Dave, Dave2, and Lindsley. Claim 75 has been rewritten as new dependent claim 125 to define patentably over Dave, Dave2, and Lindsley and any combination thereof.
Applicant submits that claim 125 is independently patentable over Dave, Dave2, and Lindsley and any combination therefore for the same reasons as given in item 15 above.

Additional comments: The last O.A. said that "In addition, Dave teaches the process being is a subinterval of an interval or a full interval that begins at the earliest time that the corresponding being converted asynchronous process can make a request for execution, and ends at a time equal to the sum of the earliest time *("Each periodic task graph has an earliest start time (est), period, and deadline (do). Each task of a periodic task graph inherits the task graph's period. Each task in a periodic task graph can have a different deadline. Hard aperiodic task graphs have a specified deadline which must be met. Aperiodic task graphs are characterized by a parameter, .UPSILON., denoting the minimum time interval between two consecutive instances of an aperiodic task graph. An aperiodic task graph may start at any time." col.5, lines 54-67 through col. 6, lines 1-4).* "Official Notice" is taken that both the concept and advantages of providing that making an executing request for the length of a period minus one is well known and expected in the art. It would have been obvious to one of ordinary skill in the art at the time the invention was made to include requesting the length of the period minus one to the existing method in order to ensure that the new process will fit into the time slot for it."

Applicant respectfully disagrees with the above "Official Notice", and requests that documentary proof be provided, and the data be stated as specifically as possible, and the facts be supported, under M.P.E.P Section 2144.03 and 37 CFR 1.104(d)(2) for the "Office Notice" position that "both the concept and advantages of providing that making an executing request for the length of a period minus one is well known and expected in the art. It would have been obvious to one of ordinary skill in the art at the time the invention was made to include requesting the length of the period minus one to the existing method in order to ensure that the new process will fit into the time slot for it."

The reasons that Applicant disagrees with the above "Official Notice" are as follows:

1. Applicant submits that this is a misunderstood reference, as the reference clearly does not teach what the O.A. relies upon it as supposedly teaching, that is, it does not teach the feature in claim 125.

2. Only a small part of claim 76 is quoted above. The full claim should be, "A method as defined in claim 58 including, prior to generating the pre-run-time schedule, determining whether each asynchronous process should or should not be converted into a new periodic process, converting a subset of a predetermined set of asynchronous processes having a worst-case computation time, minimum time between two requests characteristics and deadline constraints which have been determined to be convertible, into a set of new periodic processes having release time, worst-case computation time, period, deadline, and permitted range of offset constraints, wherein a permitted range of offset of each new periodic process being is a subinterval of an interval or a full interval that begins at the earliest time that the corresponding being converted asynchronous process can make a request for execution, and ends at a time equal to the sum of the earliest time that said being converted asynchronous process can make a request for execution plus the period length of the new periodic process minus one time unit."

3. Applicant submits that claim 125 is independently patentable over Dave, Dave2, and Lindsley and any combination therefore for the same reasons as given in item 15 above.

4. The art of how to convert an asynchronous process to a new periodic process is not merely "synchronization" as suggested by the last O.A., it is one of the most important,

yet least understood, and under-studied techniques in the field of real-time computing. Applicant's papers related to real-time computing have been reprinted in two IEEE Computer Society Tutorial collections and are also widely referenced in textbooks on real-time systems. Applicant is internationally well-known as an expert in real-time computing, and Applicant has taken a special interest in this particular technique for over 20 years, yet it had taken Applicant many, many years before Applicant realized and invented the technique shown by claim 125, hence Applicant can attest to the fact that the technique shown in claim 125 is far, far from obvious. Applicant is not surprised at all by the fact that no prior art has been found that meets the features shown in claim 125, because, to Applicant's knowledge, up to even today, no one has published a similar invention.

24. The last O.A. rejected dependent claim 78 on Dave, Dave2, and Lindsley. Claim 78 has been rewritten as new dependent claim 127 to define patentably over Dave, Dave2, and Lindsley and any combination thereof.
Applicant submits that claim 127 is independently patentable over Dave, Dave2, and Lindsley and any combination therefore for the same reasons as given in item 15 above.

Additional comments: The last O.A. said that "Referring to claim 78, Dave teaches A method as defined in claim 58, including generating the pre-run-time schedule as a feasible two-part pre-run-time-schedule for execution of periodic processes that may have non-zero offsets (a) an initial part which may be of zero length, and (b) a repeating part having length which is equal to a least common multiple of lengths of the periods of the periodic processes, all executions of all periodic processes within a time interval of length equal to the length of the least common multiple of the periodic process periods being included in the repeating part of the pre-run-time schedule, wherein all said specified constraints being satisfied for all executions of all periodic processes within both said initial part and said repeating part, and using any offset value in a permitted range of offsets of each periodic process, including any offset value in the permitted range of offsets of any new periodic process that may have been converted from an asynchronous

process, to generate said feasible pre-run-time schedule. *("The hyperperiod of the system is computed as the least common multiple (LCM) of the periods of the various periodic task graphs in the specification. According to traditional real-time computing theory, a set of periodic tasks graphs has a feasible schedule if and only if it is schedulable in the hyperperiod." col. 7, lines 33-53).* It is notoriously well known in the art of computer programming that variables can be (and most commonly are) set to zero as initial conditions and can change to non-zero values. It would have been obvious to one of ordinary skill in the art at the time the invention was made to include the feature of initializing variables because it is standard convention/practice in the art of computer science programming. At the initial or starting state, it is common that zero items have occurred and once past the initial state, it is common that non-zero data has occurred, for example."

Applicant respectfully disagrees with the above statements and submits that claim 78 is unobvious and is independently patentable over Dave, Dave2, and Lindsley and any combination therefore for the following reasons.

1. When periodic processes have non-zero offsets, then often the only correct schedule is a two-part schedule consisting of an initial part and a repeating-part. Dave uses only a "one-part" schedule with length equal to the least common multiple of the process periods. In fact using only a "one-part" schedule with length equal to the least common multiple of the process periods can lead to the generation of erroneous schedules when periodic processes have non-zero offsets.

The fact that Dave and Dave2 are not aware of this fact alone shows that the concept of a two-part schedule consisting of an initial part and a repeating-part is unobvious.

2. The validity of the statement "According to traditional real-time computing theory, a set of periodic task graphs has feasible schedule if and only if it is schedulable in the hyperperiod," depends on what constraints on the tasks exist, and what scheduling method is used. It is well known (since 1981) that if the following conditions hold: (a) all periodic tasks are completely preemptable, (b) no tasks have non-zero offsets, and (c) if

the scheduling method is earliest-deadline-first, then this statement is true, but when these conditions do not hold, then this statement can be false.

Again, the fact that Dave and Dave2 do not know the latter fact, also in itself shows that the concept of a two-part schedule consisting of an initial part and a repeating-part is unobvious.

3. When it is unavoidable that the schedule must be a two-part schedule consisting of an initial part and a repeating-part, then there are other previously unsolved problems, such as how to determine at which point does the repeating part begin, and what will be the length of the repeating part under exactly what conditions? This is one of the previously unanswered problems that Applicant's invention has solved. (In fact, if the constraints are different and the scheduling method is different, then the answers to these questions can be quite different.

Again, Dave and Dave2 would not have known this, which again shows that it is unobvious.

4. The assumptions we make do not include performing unknown random tasks like "initializing non-zero variables". All that is assumed is that each process has a certain "permitted range of offsets, that is, the time intervals during which that process can start its first period. As soon as the first period of a process is started, that process must start regularly doing a specified amount of work in each period.

25. The last O.A. rejected dependent claim 79 on Dave, Dave2, and Lindsley. Claim 79 has been rewritten as new dependent claim 128 to define patentably over Dave, Dave2, and Lindsley and any combination thereof.

Applicant submits that claim 128 is independently patentable over Dave, Dave2, and Lindsley and any combination therefore for the same reasons as given in item 15 above.

26. The last O.A. rejected dependent claim 81 on Dave, Dave2, and Lindsley. Claim 81 has been rewritten as new dependent claim 131 to define patentably over Dave, Dave2, and Lindsley and any combination thereof.

Applicant submits that claim 131 is independently patentable over Dave, Dave2, and Lindsley and any combination therefore for the same reasons as given in item 15 above.

27. The last O.A. rejected dependent claims 83-85, 89, 91, 95 on Dave, Dave2, and Lindsley. Claims 83-85, 89, 91, 95 has been rewritten as new dependent claims 134-136, 137, 138, 141 to define patentably over Dave, Dave2, and Lindsley and any combination thereof.

Applicant submits that claim 134-136, 137, 138, 141 is independently patentable over Dave, Dave2, and Lindsley and any combination therefore for the same reasons as given in item 15 above.

28. The last O.A. rejected dependent claim 86 on Dave, Dave2, and Lindsley. Claim Applicant has cancelled claim 86 as Applicant considers it to be redundant over other rewritten claims.

29. The last O.A. rejected dependent claim 87 on Dave, Dave2, and Lindsley. Claim Applicant has cancelled claim 87 as Applicant considers it to be redundant over other rewritten claims.

30. The last O.A. rejected dependent claim 88 on Dave, Dave2, and Lindsley. Claim Applicant has cancelled claim 88 as Applicant considers it to be redundant over other rewritten claims.

31. The last O.A. rejected dependent claim 90 on Dave, Dave2, and Lindsley. Claim Applicant has cancelled claim 90 as Applicant considers it to be redundant over other rewritten claims.

32. The last O.A. rejected dependent claim 92 on Dave, Dave2, and Lindsley. Claim Applicant has cancelled claim 92 as Applicant considers it to be redundant over other rewritten claims.

33. The last O.A. rejected dependent claim 94 on Dave, Dave2, and Lindsley. Claim 94 has been rewritten as new dependent claim 140 to define patentably over Dave, Dave2, and Lindsley and any combination thereof.
Applicant submits that claim 140 is independently patentable over Dave, Dave2, and Lindsley and any combination therefore for the same reasons as given in item 15 above.

34. The last O.A. rejected dependent claim 97 on Dave, Dave2, and Lindsley. Claim 97 has been rewritten as new dependent claim 143 to define patentably over Dave, Dave2, and Lindsley and any combination thereof.
Applicant submits that claim 143 is independently patentable over Dave, Dave2, and Lindsley and any combination therefore for the same reasons as given in item 15 above.

35. The last O.A. rejected dependent claim 98 on Dave, Dave2, and Lindsley. Claim 98 has been rewritten as new dependent claim 144 to define patentably over Dave, Dave2, and Lindsley and any combination thereof.
Applicant submits that claim 144 is independently patentable over Dave, Dave2, and Lindsley and any combination therefore for the same reasons as given in item 15 above.

36. The last O.A. rejected dependent claim 99 on Dave, Dave2, and Lindsley. Claim 99 has been rewritten as new dependent claim 145 to define patentably over Dave, Dave2, and Lindsley and any combination thereof.
Applicant submits that claim 145 is independently patentable over Dave, Dave2, and Lindsley and any combination therefore for the same reasons as given in item 15 above.

37. The last O.A. rejected dependent claim 103 on Dave, Dave2, and Lindsley. Claim 103 has been rewritten as new dependent claim 149 to define patentably over Dave, Dave2, and Lindsley and any combination thereof.
Applicant submits that claim 149 is independently patentable over Dave, Dave2, and Lindsley and any combination therefore for the same reasons as given in item 15 above.

38. The last O.A. rejected dependent claim 104 on Dave, Dave2, and Lindsley. Claim 81 has been rewritten as new dependent claim 115 to define patentably over Dave, Dave2, and Lindsley and any combination thereof.
Applicant submits that claim 115 is independently patentable over Dave, Dave2, and Lindsley and any combination therefore for the same reasons as given in item 15 above.

Additional comments: The last O.A. said that "Dave fails to explicitly teach a method as defined in claim 58, wherein said predetermined constraints and relations further comprise precedence relations. However, "Official Notice" is taken that both the concept and advantages of providing that predetermined constraints can be comprised of precedence relations is well known and expected in the art. It would have been obvious to one of ordinary skill in the art at the time the invention was made to include the feature of having precedence constraints as predetermined constraints to the existing method for the reason of using current/recent data into the system."

Applicant respectfully disagrees with the above "Official Notice", and requests that documentary proof be provided, and the data be stated as specifically as possible, and the facts be supported, under M.P.E.P Section 2144.03 and 37 CFR 1.104(d)(2) for the "Office Notice" position that "both the concept and advantages of providing that predetermined constraints can be comprised of precedence relations is well known and expected in the art. It would have been obvious to one of ordinary skill in the art at the time the invention was made to include the feature of having precedence constraints as predetermined constraints to the existing method for the reason of using current/recent data into the system."

The reasons that Applicant disagrees with the above "Official Notice" are as follows:
1. Applicant's invention is classified in a **crowded art** (a prior art patent cited by the O.A. states that, *"There is a vast amount of literature in the area of scheduling of soft and hard aperiodic tasks", Dave, col. 2, lines 47-48*); therefore, even a small step forward should be regarded as significant.

2. How to integrate precedence constraints with many other types of complex constraints while at the same time providing proof and guarantee that all specified constraints will be met before run-time can be very complex and unobvious. This is underscored by the fact that, the most widely known and most intensively studied techniques of scheduling, priority scheduling, still has not been able to provide a proof and guarantee that all specified constraints will be met before run-time when the specified constraints include general precedence relations combined with other complex constraints such as exclusion constraints and offset constraints despite more than four decades of intensive research.

39. The last O.A. rejected dependent claim 105, and 107 on Dave, Dave2, and Lindsley. Claim 105 and 107 have been rewritten as new dependent claims 115 and 124 to define patentably over Dave, Dave2, and Lindsley and any combination thereof. Applicant submits that claim 115 and 124 is independently patentable over Dave, Dave2, and Lindsley and any combination therefore for the same reasons as given in item 15 above.

The last O.A. rejected dependent claim 106 on Dave, Dave2, and Lindsley. Claim 106 has been rewritten as new dependent claim 119 to define patentably over Dave, Dave2, and Lindsley and any combination thereof.
Applicant submits that claim 119 is independently patentable over Dave, Dave2, and Lindsley and any combination therefore for the same reasons as given in item 15 above.

Additional comments: The last O.A. said that "Dave in view of Lindsley teaches scheduling, within the pre-run-time schedule, a difference between the end time and the beginning time of each of said periodic time slots with sufficient time capacity for execution of asynchronous processes that have less latitude than considered ones of periodic processes in meeting their respective deadlines. In addition, Dave teaches that processes in the schedule fit into time slots *("For each aperiodic task, as explained before, the algorithm positions the execution slots throughout the hyperperiod after scheduling the first execution slot. If the execution slot cannot be allocated at the*

required instant, the algorithm schedules its at the earliest possible time and repositions the remaining slots to ensure that the deadlines are always met." Dave, col. 12, lines 20-26). Applicant submits that this is a misunderstood reference, as the reference clearly does not teach what the O.A. relies upon it as supposedly teaching, that is, it does not teach the feature in claim 119. Applicant has discussed this in more detail in item 11.2.1. and 11.2.2. above

40. The last O.A. rejected dependent claim 109 on Dave, Dave2, and Lindsley. Claim 109 have been rewritten as new dependent claims 125 to define patentably over Dave, Dave2, and Lindsley and any combination thereof.
Applicant submits that claim 125 is independently patentable over Dave, Dave2, and Lindsley and any combination therefore for the same reasons as given in item 15 above

41. The last O.A. rejected dependent claim 110 on Dave, Dave2, and Lindsley. Claim 110 has been rewritten as new dependent claim 127 to define patentably over Dave, Dave2, and Lindsley and any combination thereof.
Applicant submits that claim 127 is independently patentable over Dave, Dave2, and Lindsley and any combination therefore for the same reasons as given in item 15 above

42. The last O.A. rejected dependent claim 113 on Dave, Dave2, and Lindsley. Claim 113 has been rewritten as new dependent claims 151 to define patentably over Dave, Dave2, and Lindsley and any combination thereof.
Applicant submits that claim 151 is independently patentable over Dave, Dave2, and Lindsley and any combination therefore for the same reasons as given in item 15 above

43. The Rejection Of Claim 77 Under 35 USC § 103 On Dave (US 6,178,542 B1), Lindsley (US 6,430,593 B1), And Matsumoto (US5,448, 732) Is Overcome

44. The last O.A. rejected dependent claim 77 on Dave, Lindsley and Matsumoto. Claim 77 has been rewritten as new dependent claim 126 to define patentably over Dave, Lindsley and Matsumoto and any combination thereof. Applicant requests

reconsideration of this rejection, as now applicable to claim 126, for the following reasons:

(1) There is no justification, in Dave, Lindsley, and Matsumoto, or in any other prior art separate from Applicant's disclosure, which suggests that these references be combined, much less combined in the manner proposed.
(2) The proposed combination would not be physically possible or operative.
(3) Even if Dave, Lindsley, and Matsumoto were to be combined in the manner proposed, the proposed combination would not show all of the novel physical features of claim 126.
(4) The novel features of claim 126 produce new and unexpected results and hence are unobvious and patentable over these references.

44.1. Dave, Lindsley, and Matsumoto Do Not Contain Any Justification To Support Their Combination, Much Less In The Manner Proposed

With regard to the proposed combination of Dave, Lindsley, and Matsumoto, it is well known that in order for any prior-art references themselves to be validly combined for use in a prior-art § 103 rejection, *the references themselves* (or some other prior art) must suggest that they be combined. E.g., as was stated in In re Sernaker, 217 U.S.P.Q. 1, 6 (C.A.F.C. 1983):

> "[P]rior art references in combination do not make an invention obvious unless something in the prior art references would suggest the advantage to be derived from combining their teachings."

That the suggestion to combine the references should not come from applicant was forcefully stated in Orthopedic Equipment Co. v. United States, 217 U.S.PQ. 193, 199 (CAFC 1983):

> "It is wrong to use the patent in suit [here the patent application] as a guide through the maze of prior art references, combining the right references in the

right way to achieve the result of the claims in suit [here the claims pending]. Monday morning quarterbacking is quite proper when resolving the question of nonobviousness in a court of law [here the PTO]."

As was further stated in Uniroyal, Inc. v. Rudkin-Wiley Corp., 5 U.S.P.Q.2d 1434 (C.A.F.C. 1988), "[w]here prior-art references require selective combination by the court to render obvious a subsequent invention, there must be some reason for the combination other than the hindsight gleaned from the invention itself. . . . *Something in the prior art must suggest the desirability and thus the obviousness of making the combination.*" [Emphasis supplied.]

In line with these decisions, the Board stated in Ex Parte Levengood, 28 U.S.P.Q.2d 1300 [P.T.O.B.A.&]. 1993):

"In order to establish a *prima facie* case of obviousness, it is necessary for the examiner to present evidence, preferably in the form of some teaching, suggestion, incentive or inference in the applied prior art, or in the form of generally available knowledge, that one having ordinary skill in the art *would have been led to* combine the relevant teachings of the applied references in the proposed manner to arrive at the claimed invention. . . . That which is within the capabilities of one skilled in the art is not synonymous with obviousness, ... That one can *reconstruct* and/or explain the theoretical mechanism of an invention by means of logic and sound scientific reasoning does not afford the basis for an obviousness conclusion unless that logic and reasoning also supplies sufficient impetus to have led one of ordinary skill in the art to combine the teachings of the references to make the claimed invention. . . . Our reviewing courts have often advised the Patent and Trademark Office that it can satisfy the burden of establishing a *prima facie* case of obviousness only be showing some objective teaching in either the prior art, or knowledge generally available to one of ordinary skill in the art, that `would lead' that individual `to combine the relevant teachings of the references." ... Accordingly, an examiner cannot establish obviousness by locating references which describe various aspects of a patent application's invention without also providing

evidence of the motivating force which would impel one skilled in the art to do what the patent applicant has done."

In the present case, there is no reason given in the last O.A. to support the proposed combination, other than the statement *"Referring to claim 77, Dave fails to explicitly* teach prior to generating the pre-run-time schedule, determining whether each asynchronous process should or should not be converted into a new periodic process by a ratio or processing capacity. However, Matsumoto teaches a method of determining whether each asynchronous process should or should not be converted into a new periodic process by calculating whether a ratio of processing capacity of the processor which is required to be reserved for new periodic processes, to processor capacity that is required for the asynchronous process if left unconverted, exceeds a predetermined threshold value. *("Each of [1], [2], and [3] is a condition for improving the theoretical effectiveness, and each of [4] and [5] is a condition for doing the same by determining "n" heuristically, or from experience. Depending on the application which is running, "n" is adjusted in order to improve efficiency. With respect to conditions [4] and [5], instead of the number of processes waiting for synchronization, the ratio of the number of processors in the group to the number of processors waiting for synchronization in the group is used," col. 6, lines 25-35*). It would have been obvious to one of ordinary skill in the art at the time the invention was made to include the feature of synchronizing with respects to a ratio value of processing capacity for the reason of increasing the control of the system. This ratio tells the processor when it can stop waiting for synchronization to begin, for example. As mentioned earlier, it is common knowledge in the art of task management and process synchronization that converting asynchronous processes to synchronous ones is merely synchronization. In addition, Dave in view of Lindsley, and in further view of Matsumoto fail to explicitly teach using predetermined thresholds to determine a state in change. However, "Official Notice" is taken that both the concept and advantages of providing that the use of thresholds is well known and expected in the art. It would have been obvious to one of ordinary skill in the art at the time the invention was made to include thresholds to the existing method for the reason of increasing the control by being able to set limits or boundaries which determine one state over another.

In this specific case, synchronization would begin after the threshold is reached." (Last O.A.)

Applicant respectfully disagrees with the above "Official Notice", and requests that documentary proof be provided, and the data be stated as specifically as possible, and the facts be supported, under M.P.E.P Section 2144.03 and 37 CFR 1.104(d)(2) for the "Office Notice" position that "the use of thresholds is well known and expected in the art. It would have been obvious to one of ordinary skill in the art at the time the invention was made to include thresholds to the existing method for the reason of increasing the control by being able to set limits or boundaries which determine one state over another. In this specific case, synchronization would begin after the threshold is reached."

1. Matsumoto fails to show any of the important features of claim 126.
2. The art of how to convert an asynchronous process to a new periodic process is not merely "synchronization" as suggested by the last O.A., it is one of the most important, yet least understood, and under-studied techniques in the field of real-time computing. Applicant's papers related to real-time computing have been reprinted in two IEEE Computer Society Tutorial collections and are also widely referenced in textbooks on real-time systems. Applicant is internationally well-known as an expert in real-time computing, and Applicant has taken a special interest in this particular technique for over 20 years, yet it had taken Applicant many, many years before Applicant realized and invented the technique shown by claim 126, hence Applicant can attest to the fact that the technique shown in claim 126 is far, far from obvious.
3. As can been seen in Fig. 26 of the drawings, and paragraph [0174], determining the ratio of processing capacity of the processor which is required to be reserved for new periodic processes, to processor capacity that is required for the asynchronous process if left unconverted, requires an elaborate procedure that is far from obvious. Hence Applicant is not surprised at all by the fact that no prior art has been found that meets the features shown in claim 126, because, to Applicant's knowledge, up to even today, no one has published a similar invention.

However, the fact that the words "processors waiting for synchronization", "the ratio of the number of processors" "asynchronous" appear in the reference is not sufficient to gratuitously and selectively combine parts of one reference (Matsumoto's multiprocessor system) with another two references in order to meet Applicant's novel claimed combination of features.

Note that:

44.1.1. The meaning of the term "synchronous" in Lindsley is inherently different from the meaning of "periodic" in Applicant's invention as defined by claim 126 as shown below:

44.1.1.(a) Lindsley uses the term "synchronous" when describing "synchronous task commands". *("The TSA accepts commands from tasks called `synchronous' task commands. These commands are synchronous from the point of view that the task may not issue another synchronous task command until the previous synchronous task command has been completed. It is allowable for the task to perform other activity after issuing a synchronous task command as long as the task verifies that the previous task has been completed prior to issuing another synchronous task command." Lindsley, col. 6, lines 47-55.)* It is clear that in Lindsley there is no periodic constraint on "synchronous" task commands, i.e., synchronous task commands are not constrained to execute strictly once in each fixed period of time.

44.1.1.(b) In contrast, in Applicant's invention as defined by claim 126, "a periodic process consists of a computation that is executed repeatedly, once in each fixed period of time. (Applicant's specification, paragraph [0113]). Applicant's definition of a periodic process, is adopted universally in the field of real-time computing and is clearly different from the meaning of "synchronous" as defined in Lindsley.

44.1.2. The meaning of the term "*synchronization*" in Lindsley is also inherently different from the meaning of "*converting an asynchronous process to a new periodic process*" in Applicant's invention as defined by claim 126 as shown below:

44.1.2.(a) In Lindsley, tasks are synchronized using "events" which are certainly not always periodic.*("Tasks are typically synchronized using "events". An event is used to indicate that an activity has taken place, such as data arrival, time-out, etc. Thus, an event may indicate execution of a task, an interrupt service routine or the like. Events are counted using semaphores. Semaphores synchronize the event producer and the event consumer ..." Lindsley, col. 2, lines 4-10.)*

("If a task that processes data buffers pends for the semaphore that represents data buffers, the task is synchronized to the data buffer generation. If data buffers are available, the semaphore count is greater than zero. Task pend requests on the semaphore a llow the task to continue. If data buffers are not available, the semaphore count is less than or equal to zero, the task does not have data for processing and will block execution". Lindsley, col. 2, lines 52-61.)

44.1.2.(b) In contrast, in Applicant's invention as defined by claim 126, "*converting an asynchronous process to a new periodic process*" means converting a process that can be executed at random times, to a process that will be executed once in each fixed period of time.

44.1.3.(a) In Matsumoto, as with Lindsley, there is no notion of periodic processes, no notion of deadlines or any kind of timing constraints.

The above evidence, clearly shows that the last O.A.'s reason for combining Dave, Lindsley, and Matsumoto to find obviousness of claim 126, i.e., *("It is common knowledge in the art of task management and process synchronization that converting an asynchronous process to a new periodic process (or a synchronous process) is known as synchronization,"* is totally unfounded.

Applicant therefore submits that combining Dave, Lindsley, and Matsumoto is not legally justified and is therefore improper. Thus Applicant submits that the rejection on these references is also improper and should be withdrawn.

Applicant respectfully requests, if the claims are again rejected upon any combination of references, that the Examiner include an explanation, in accordance with M.P.E.P. § 706.02, Ex parte Clapp, 27 U.S.P.Q. 972 (P.O.B.A. 1985), and Ex parte Levengood, supra, a "factual basis to support his conclusion that it would have been obvious" to make the combination,

44.2. Even if Dave, Lindsley, and Matsumoto Were To Be Combined In The Manner Proposed, The Proposed Combination Would Not Show All The Novel Features Of Claim 126.

However even if the combination of Dave, Lindsley, and Matsumoto were justified, claim 126 would still have novel and unobvious features over the proposed combination.

44.2.1. Neither Dave, nor Lindsley, nor Matsumoto, nor any possible combination thereof show the feature of automatically generating a pre-run-time schedule in which predetermined constraints comprising worst-case computation time, period, minimum time between two consecutive exclusion relations, deadline, permitted range of offset constraints, precedence relations are satisfied. (Discussion on Dave's lack of ability to satisfy exclusion constraints is provided in item 11.1. above and is equally applicable to Dave and Dave2 and is hereby included here by reference.)

Claim 126 clearly distinguishes over Dave, Lindsley, Matsumoto or any possible combination thereof, since it recites

"*automatically generating a pre-run-time schedule comprising mapping from a set of periodic process executions to a sequence of time slots on one or more processor time*

axes, each of the time slots having a beginning time and an end time, reserving each one of the time slots for execution of one of the periodic processes, the positions of the end time and the beginning time of each of the time slots being such that execution of the periodic processes,

including satisfaction of predetermined constraints comprising

(1) worst-case computation times for periodic processes and asynchronous processes,

(2) period for periodic processes,

(3) minimum time between two consecutive requests for asynchronous processes,

(4) deadline for periodic processes and asynchronous processes,

(5) permitted range of offset constraints for periodic processes wherein a permitted range of offset of a periodic process comprising an interval that begins at a lower bound value and ends at an upper bound value which may be equal to the lower bound value, the duration of the time interval between the beginning of the first period of said periodic process and time zero must be greater than or equal to said lower bound value and less than or equal to said upper bound value,

(6) precedence relations for periodic processes wherein each precedence relation being defined between a pair of processes comprising a first process and a second process, both said first process and said second process being periodic processes, said first process precedes said second process, execution of said second process only allowed to start after said first process has completed its execution,

(7) exclusion relations for periodic and asynchronous processes wherein each exclusion relation being defined between a pair of processes comprising a first process and a second process, said first process being either a periodic process or an asynchronous process and said second process being either a periodic process or an asynchronous process, said first process excludes said second process, no execution of said second process being allowed to occur between the time that said first process starts its execution and the time that said first process completes its computation,

can be completed between the beginning time and end time of respective time slots,

including the step of converting one or more asynchronous processes into corresponding new periodic processes prior to the mapping step, and mapping new periodic processes to time slots in a manner similar to mapping of other periodic processes, such that said predetermined constraints will be satisfied".

Neither Dave, nor Lindsley, nor Matsumoto nor any possible combination thereof, show the feature of *automatically generating a pre-run-time schedule including satisfaction of predetermined constraints comprising*
"exclusion relations for periodic and asynchronous processes wherein each exclusion relation being defined between a pair of processes comprising a first process and a second process, said first process being either a periodic process or an asynchronous process and said second process being either a periodic process or an asynchronous process, said first process excludes said second process, no execution of said second process being allowed to occur between the time that said first process starts its execution and the time that said first process completes its computation".
(Discussion on Dave's lack of this feature is provided in item 11.1. above and is equally applicable to Dave and Dave2, and is hereby included here by reference.)

Note that Lindsley performs synchronization only at run-time, NOT before run-time, so it is not capable of satisfying any constraints before run-time, which Applicant's invention, as defined by claim 126 would be capable of doing.

44.2.2. Neither Dave, nor Lindsley, nor Matsumoto, nor any possible combination thereof show the feature of permitted range of offset constraints for periodic processes

Claim 126 clearly distinguishes over any combination of Dave, Lindsley, Matsumoto since it recites

"including satisfaction of predetermined constraints comprising

...

(4) *permitted range of offset constraints for periodic processes wherein a permitted range of offset of a periodic process comprising an interval that begins at a lower bound value and ends at an upper bound value which may be equal to the lower bound value, the duration of the time interval between the beginning of the first period of said periodic process and time zero must be greater than or equal to said lower bound value and less than or equal to said upper bound value, n,"*

Neither Dave, nor Lindsley, nor Matsumoto, nor any possible combination thereof show the feature of satisfying predetermined constraints comprising "*permitted range of offset constraints for periodic processes wherein a permitted range of offset of a periodic process comprising an interval that begins at a lower bound value and ends at an upper bound value which may be equal to the lower bound value, the duration of the time interval between the beginning of the first period of said periodic process and time zero must be greater than or equal to said lower bound value and less than or equal to said upper bound value, n,"*

44.2.3. Neither Dave, nor Lindsley, nor Matsumoto, nor any possible combination thereof show the feature of determining whether each asynchronous process should or should not be converted into a new periodic process by calculating whether a ratio of processing capacity of the processor which is required to be reserved for new periodic processes, to processor capacity that is required for the asynchronous process if left unconverted, exceeds a predetermined threshold value.

Claim 124 clearly distinguishes over any combination of Dave, Lindsley, Matsumoto since it recites

"A method as defined in claim 115 including, prior to generating the pre-run-time schedule, determining whether each asynchronous process should or should not be converted into a new periodic process, converting a subset of a predetermined set of asynchronous processes having worst-case computation time, minimum

time between two requests characteristics and deadline constraints, which have been determined to be convertible, into a set of new periodic processes having worst-case computation time, period, deadline, and permitted range of offset constraints, and reducing possible timing conflicts with other periodic or asynchronous processes with less latitude in meeting their deadlines, by taking into consideration the computation time requirements of the latter processes when determining the deadline of the new periodic process".

Claim 126 recites

A method as defined in claim 124, in which the determining step is performed by calculating whether a ratio of processing capacity of the processor which is required to be reserved for new periodic processes, to processor capacity that is required for the asynchronous process if left unconverted, exceeds a predetermined threshold value.

Neither Dave, nor Lindsley, nor Matsumoto, nor any possible combination thereof show the feature of satisfying predetermined constraints comprising "*determining whether each asynchronous process should or should not be converted into a new periodic process by calculating whether a ratio of processing capacity of the processor which is required to be reserved for new periodic processes, to processor capacity that is required for the asynchronous process if left unconverted, exceeds a predetermined threshold value.*

44.4.The Suggested Combination Of Dave, Lindsley, and Matsumoto Would Not Be Physically Possible Or Operative.

There is plenty of unequivocal evidence that show that the suggested combination of Dave, Lindsley, and Matsumoto would not be physically possible or operative, here is just a few of them:

44.4.1. Both Matsumoto and Lindsley describe methods which are totally void of any consideration of quantitative timing constraints.

Matsumoto and Lindsley does not take into account:

(f) worst-case computation time values of asynchronous or periodic processes,

(g) deadline values of asynchronous or periodic processes,

(h) period values of periodic processes

(i) minimum time between two requests of asynchronous processes

(j) permitted range of offset values for periodic processes.

44.4.2. It is notoriously well-known, and common sense would also dictate that, if any single one of the above quantitative timing constraints is not taken into consideration, then there is absolutely no hope of satisfying the timing constraints.

44.4.3. The references of Dave does not contain any teaching, that suggests that their method could be physically combined with the teachings of Lindsley or Matsumoto. Neither does the reference of Lindsley contain any teaching, that suggests the teaching of Lindsley could be physically combined with the teachings of Dave and Matsumoto, or any other combination could work.

44.4.4. There is no evidence in the prior art that suggests that the references of Dave, Lindsley, and Matsumoto could be combined to produce an operative method.

44.4.5. Combining Dave, Lindsley, and Matsumoto will NOT produce an operative method that will cover all the features of claim 126 as Lindsley and Matsumoto do not concern themselves with timing.

44.4.6. As shown in item 44.1.1 above, neither Lindsley nor Matsumoto do not even consider periodic processes.

44.4.7. As shown in item 44.1.1 above, the last O.A.'s citation of Lindsley is a misunderstood reference. The reference does not teach what the last O.A. relies upon it as supposedly teaching. The main task feature of "synchronous" is not identical to "periodic" as the last O.A. assumed.

44.4.8. The reference of Lindsley relies on the use of general semaphores. It is notoriously well known that general semaphores are not suitable for use in systems with hard deadlines and may prevent the satisfaction of hard deadline constraints altogether. Here is just one simple example: general semaphores are subject to deadlock and various forms of starvation, and just detecting deadlocks alone is an NP-Hard problem, not to mention the total breakdown in any capability to meet any kind of timing constraints when a deadlock does occur. The entire specification of Lindsley completely ignores this problem. As to be expected, the references of Dave and Matsumoto also completely ignore this problem.

44.4.9. Even if Dave is operative when functioning alone, and even if it is structurally possible to combine it with Lindsley, and Matsumoto, the resulting method will NOT be inoperative for the purpose of satisfying hard timing constraints at the very least because of the possibility of deadlock in Lindsley's method.

44.4.10 Actually, Matsumoto readily acknowledges that his method may include processes that are deadlocked *("All of the processes in the group of processes concerned are dispatched to processors and waiting for synchronization at one time; this event occurs due to programming errors (deadlock)."col. 6, lines 5-9.)*

44.4. The Novel Features Of Claim 126 Produce New And Unexpected Results And Hence Are Unobvious And Patentable Over Any Possible Combination Of Dave, Lindsley and Matsumoto Under § 103

Claim 126 provides the following combination of features that have never before been provided simultaneously:

(1) Applicant's invention as defined by claim 126 provides the capability to enforce exclusion relations on pairs of processes that can be either (i) asynchronous processes that are not converted into new periodic processes and hence are not mapped into time slots in the pre-run-time schedule, or (ii) asynchronous processes that are converted into new periodic processes and hence are mapped into time slots in the pre-run-time schedule, or (iii) periodic processes that are mapped into time slots in the pre-run-time schedule, thus providing the capability to prevent errors caused by more than one process simultaneously accessing shared resources such as data in systems of one or more processors while also providing the capability to select precisely which pairs of process' executions should not overlap in time when they access shared data thus maximizing the system's flexibility in meeting deadline constraints.

Neither Dave, nor Lindsley, nor Matsumoto show this feature.

(2) Applicant's invention as defined by claim 126 simultaneously provides the capability to increase the flexibility of meeting deadline constraints when there is flexibility in assigning an offset value for a periodic process.

Neither Dave, nor Lindsley, nor Matsumoto show this feature.

(3) Applicant's invention as defined by claim 126 provides the above combination of features, while providing the capability to handle processes that can be either (i) asynchronous processes that are not converted into new periodic processes and hence are not mapped into time slots in the pre-run-time schedule, or (ii) asynchronous processes that are converted into new periodic processes and hence are mapped into time slots in the pre-run-time schedule, or (iii) periodic processes that are mapped into time slots in the pre-run-time schedule, thus obtaining the advantages of pre-run-time scheduling including ability to use the information in the pre-run-time schedule to achieve greater predictability, ability to handle complex constraints, lower run-time overhead, and in general greatly increase the efficiency of scheduling; and the advantages of run-time scheduling including ability to handle asynchronous processes with very short deadlines that cannot be

converted into periodic processes or will waste too much processor capacity if converted into periodic processes, while providing a guarantee that all the constraints, including hard deadlines, will be satisfied before run-time. Neither Dave, nor Lindsley, nor Matsumoto show this feature show this combination of features.

A. Applicant's invention achieves **unexpected results**: A system with all the above important features combined together, has never been realized before. The combination of results achieved by Applicant's invention are new and vastly superior compared to that of Dave, Lindsley, and Matsumoto or any combination thereof.

B. Applicant's invention is classified in a **crowded art** (a prior art patent cited by the O.A. states that, *"There is a vast amount of literature in the area of scheduling of soft and hard aperiodic tasks", Dave, col. 2, lines 47-48*); therefore, even a small step forward should be regarded as significant.

Applicant therefore submits that claim 126 is patentable under § 102 and § 103 and should be allowed, since they produce new and unexpected results over Dave, Lindsley, and Matsumoto or any combination thereof.

45. The Rejection Of Claims 67-68 Under 35 USC § 103 On Dave (US 6,178,542 B1), Dave2 (US 6,086,628), Lindsley (US 6,430,593 B1) And Nilsen (US 6,438,573 B1) Is Overcome

46. The last O.A. rejected dependent claims 67 on Dave, Dave2, Lindsley, and Nilsen. Claims 67 has been rewritten as new dependent claims 121 to define patentably over Dave, Dave2, Lindsley, and Nilsen and any combination thereof.
Applicant submits that claim 121 is independently patentable over Dave, Dave2, Lindsley, and Nilsen and any combination therefore for the same reasons as given in item 15 above, and in addition, the following reasons.

46.1. Nilsen merely mentions adjusting periods, but does not offer any specific method on how to adjust periods in a context that is the same as Applicant's invention as defined in claim 146, that is, while guaranteeing that all timing constraints will be satisfied in the system. While Applicant's invention as defined in claim 121 adjusts periods before run-time and guarantees that all specified timing constraints will be satisfied. Nilsen adjusts periods during run-time and does not guarantees that all specified timing constraints will be satisfied. In fact, adjusting the periods in Nilsen's method may cause the system to run behind schedule. ("In these cases, the resource negotiator may choose to adjust task periods so that they align more evenly with the current period of the system's real-time cyclic schedule." col. 23, lines 20-23.) ("Note that the real-time executive may need to revise the time budget dynamically (if, for example, the system finds itself running behind schedule.) Fig. 13, lines -5 to -4.)

46.2. There is no suggestion, either from the references themselves, or prior art, that these references should be combined. Note that:

(a) Nilsen does NOT provide any guarantee, either before run-time, nor during run-time that all specified timing constraints, including deadline constraints, will be satisfied: Nilsen explicitly acknowledges that it is possible that the system's timing is not guaranteed:

(a1) The system may run behind schedule. ("Note that the real-time executive may need to revise the time budget dynamically (if, for example, the system finds itself running behind schedule.)," Fig. 13, lines -5 to -4.)

(a2) Time alarms may be postponed indefinitely. ("If the alarm was set before entering into the current atomic segment and the alarm time arrives while the application is still executing the body of the atomic segment, delivery of the alarm's exception is postponed until after the application leaves its atomic statement." col. 18, lines 41-45.)

(a3) Tasks can be suspended at any time. ("If this condition cannot be satisfied at the current time, suspend the task." col. 17, lines 53-54).

(b) Nilsen does not enforce exclusion constraints. ("It does not enforce mutual exclusion." col. 27, line 5-6).

46.3. Combining these references will result in an inoperative system, because of the above.

47. The last O.A. rejected dependent claims 68 on Dave, Dave2, Lindsley, and Nilsen. Claims 68 has been rewritten as new dependent claims 122 to define patentably over Dave, Dave2, Lindsley, and Nilsen and any combination thereof.
Applicant submits that claim 122 is independently patentable over Dave, Dave2, Lindsley, and Nilsen and any combination therefore for the same reasons as given in items 15 and 46 above.

48. The Rejection Of Claims 88 And 111 Under 35 USC § 103 On Dave (US 6,178,542 B1), Dave2 (US 6,086,628), Lindsley (US 6,430,593)*, and Fong (US 6,345,287 B1) Is Overcome

49. *Applicant would like to draw attention to a possible mistake in the last O.A, page 20, item 48-49: The last O.A. rejected dependent claim 80 on Dave, Dave2, and Fong; and only Dave, Dave2, and Fong were mentioned in the last O.A. comments related to claim 80. But the last O.A. comments also said that "Referring to claim 80, it rejected for the same reasons as stated in the rejection of claims 59,-64, 75, and 78." In the last O.A., page 8, item 14, claims 59,-64, 75, and 78 were rejected on Dave, Dave2, and Lindsley. Since Applicant is not sure whether to write a response based on (a) the assumption that claim 80 was rejected on Dave, Dave2, and Fong; or, (b) the assumption that claim 80 was rejected on Dave, Dave2, Lindsley, and Fong. In this amendment, Applicant will write a response base on the latter assumption, i.e. (b) the assumption that claim 80 was rejected on Dave, Dave2, Lindsley, and Fong. However, Applicant notes that the Applicant's response would have been different if assumption (a) was made.

Claim 80 has been rewritten as new independent claim 130 to define patentably over Dave, Dave2, Lindsley, and Fong and any combination thereof. Applicant requests

reconsideration of this rejection, as now applicable to claim 130, for all the reasons as stated in item 15 of this amendment, and in addition, for the following reasons:

(1) There is no justification, in Dave, Dave2, Lindsley, and Fong, or in any other prior art separate from Applicant's disclosure, which suggests that these references be combined, much less combined in the manner proposed.
(2) The proposed combination would not be physically possible or operative.
(3) Even if Dave, Dave2, Lindsley, and Fong were to be combined in the manner proposed, the proposed combination would not show all of the novel physical features of claim 130.
(4) The novel features of claim 130 produce new and unexpected results and hence are unobvious and patentable over these references.

49.1. Dave, Dave2, Lindsley, and Fong Do Not Contain Any Justification To Support Their Combination, Much Less In The Manner Proposed

With regard to the proposed combination of Dave, Dave2, Lindsley, and Fong, it is well known that in order for any prior-art references themselves to be validly combined for use in a prior-art § 103 rejection, *the references themselves* (or some other prior art) must suggest that they be combined. E.g., as was stated in In re Sernaker, 217 U.S.P.Q. 1, 6 (C.A.F.C. 1983):

> "[P]rior art references in combination do not make an invention obvious unless something in the prior art references would suggest the advantage to be derived from combining their teachings."

That the suggestion to combine the references should not come from applicant was forcefully stated in Orthopedic Equipment Co. v. United States, 217 U.S.PQ. 193, 199 (CAFC 1983):

> "It is wrong to use the patent in suit [here the patent application] as a guide through the maze of prior art references, combining the right references in the

right way to achieve the result of the claims in suit [here the claims pending]. Monday morning quarterbacking is quite proper when resolving the question of nonobviousness in a court of law [here the PTO]."

As was further stated in Uniroyal, Inc. v. Rudkin-Wiley Corp., 5 U.S.P.Q.2d 1434 (C.A.F.C. 1988), "[w]here prior-art references require selective combination by the court to render obvious a subsequent invention, there must be some reason for the combination other than the hindsight gleaned from the invention itself. . . . *Something in the prior art must suggest the desirability and thus the obviousness of making the combination.*" [Emphasis supplied.]

In line with these decisions, the Board stated in Ex Parte Levengood, 28 U.S.P.Q.2d 1300 [P.T.O.B.A.&]. 1993):

"In order to establish a *prima facie* case of obviousness, it is necessary for the examiner to present evidence, preferably in the form of some teaching, suggestion, incentive or inference in the applied prior art, or in the form of generally available knowledge, that one having ordinary skill in the art *would have been led to* combine the relevant teachings of the applied references in the proposed manner to arrive at the claimed invention. . . . That which is within the capabilities of one skilled in the art is not synonymous with obviousness, ... That one can *reconstruct* and/or explain the theoretical mechanism of an invention by means of logic and sound scientific reasoning does not afford the basis for an obviousness conclusion unless that logic and reasoning also supplies sufficient impetus to have led one of ordinary skill in the art to combine the teachings of the references to make the claimed invention. . . . Our reviewing courts have often advised the Patent and Trademark Office that it can satisfy the burden of establishing a *prima facie* case of obviousness only be showing some objective teaching in either the prior art, or knowledge generally available to one of ordinary skill in the art, that 'would lead' that individual 'to combine the relevant teachings of the references." ... Accordingly, an examiner cannot establish obviousness by locating references which describe various aspects of a patent application's invention without also providing

evidence of the motivating force which would impel one skilled in the art to do what the patent applicant has done."

In the present case, there is no reason given in the last O.A. to support the proposed combination, other than the statement *"Referring to claim 80, it is rejected for the same reasons as stated in the rejection of claims 59-64, 75, and 78. Dave in view of Dave2 fails to explicitly teach scheduling with subschedules. However, Fong teaches using subpartitions and subschedules ("subpartitions", "subschedules", col. 3, lines 6-32, and col. 3, lines 55-67, and col. 4, lines 46-65). It would have been obvious to one of ordinary skill in the art at the time the invention was made to include the feature of subschedules/subpartitions to the existing method for the reason of increasing the flexibility of the system (When only a mapping of applications to processors is provided by the higher level scheduler, there is additional flexibility and generality by allowing the lower level schedulers to make all or any subset of the scheduling decisions.", col. 3, lines 7-32.*

However, the fact that the words "subpartitions", "subschedules" (Fong, *col. 3, lines 6-32, and col. 3, lines 55-67, and col. 4, lines 46-65).* appear in the reference is not sufficient to gratuitously and selectively combine parts of one reference (Fong's gang scheduling) with another reference in order to meet Applicant's novel claimed combination of features.

Note that:

49.1.1. The meaning of the term "synchronous" in Lindsley is inherently different from the meaning of "periodic" in Applicant's invention as defined by claim 130 as shown below:

49.1.1.(a) Lindsley uses the term "synchronous" when describing "synchronous task commands". *("The TSA accepts commands from tasks called `synchronous' task commands. These commands are synchronous from the point of view that the task may not issue another synchronous task command until the previous synchronous task command has been completed. It is allowable for the task to perform other activity after*

issuing a synchronous task command as long as the task verifies that the previous task has been completed prior to issuing another synchronous task command." Fong, col. 6, lines 47-55.) It is clear that in Lindsley there is no periodic constraint on "synchronous" task commands, i.e., synchronous task commands are not constrained to execute strictly once in each fixed period of time.

49.1.1.(b) In contrast, in Applicant's invention as defined by claim 130, "a periodic process consists of a computation that is executed repeatedly, once in each fixed period of time. (Applicant's specification, paragraph [0113]). Applicant's definition of a periodic process, is adopted universally in the field of real-time computing and is clearly different from the meaning of "synchronous" as defined in Fong.

49.1.2. The meaning of the term "*synchronization*" in Lindsley is also inherently different from the meaning of "*converting an asynchronous process to a new periodic process*" in Applicant's invention as defined by claim 130 as shown below:

49.1.2.(a) In Lindsley, tasks are synchronized using "events" which are certainly not always periodic.*("Tasks are typically synchronized using "events". An event is used to indicate that an activity has taken place, such as data arrival, time-out, etc. Thus, an event may indicate execution of a task, an interrupt service routine or the like. Events are counted using semaphores. Semaphores synchronize the event producer and the event consumer ..." Fong, col. 2, lines 4-10.)*

("If a task that processes data buffers pends for the semaphore that represents data buffers, the task is synchronized to the data buffer generation. If data buffers are available, the semaphore count is greater than zero. Task pend requests on the semaphore allow the task to continue. If data buffers are not available, the semaphore count is less than or equal to zero, the task does not have data for processing and will block execution". Lindsley, col. 2, lines 52-61.)

49.1.2.(b) In contrast, in Applicant's invention as defined by claim 130, "*converting an asynchronous process to a new periodic process*" means converting a process that can be executed at random times, to a process that will be executed once in each fixed period of time.

The above evidence, clearly shows that this O.A.'s reason for combining Dave, Dave2, Lindsley, and Fong to find obviousness of claim 130, i.e., *("It is common knowledge in the art of task management that converting an asynchronous process to a new periodic process (or a synchronous process) is known as synchronization,"* is totally unfounded.

49.1.3.(a) Neither Dave, nor Dave2, nor Lindsley, nor Fong say that their methods can be combined with other scheduling methods. This is a good indication that neither Dave, nor Dave2, nor Lindsley, nor Fong can integrate their methods with another methods, because, the capability to be integrated with other scheduling methods is a valuable and marketable advantage that an inventor will never fail to claim if that capability indeed exists.

49.1.3.(b) Neither Dave, nor Dave2, nor Lindsley, nor Fong teach the method of determining the point that separates the initial part and the repeating part of the pre-run-time schedule in claim 130.

Applicant therefore submits that combining Dave, Dave2, Lindsley, and Fong is not legally justified and is therefore improper. Thus Applicant submits that the rejection on these references is also improper and should be withdrawn.

Applicant respectfully requests, if the claims are again rejected upon any combination of references, that the Examiner include an explanation, in accordance with M.P.E.P. § 706.02, Ex parte Clapp, 27 U.S.P.Q. 972 (P.O.B.A. 1985), and Ex parte Levengood, supra, a "factual basis to support his conclusion that it would have been obvious" to make the combination,

49.2. Even if Dave, Dave2, Lindsley, and Fong Were To Be Combined In The Manner Proposed, The Proposed Combination Would Not Show All The Novel Features Of Claim 130.

However even if the combination of Dave, Dave2, Lindsley, and Fong were justified, claim 130 would still have novel and unobvious features over the proposed combination.

49.2.1. Neither Dave, nor Dave2, nor Fong, nor any possible combination thereof show the feature of automatically generating a pre-run-time schedule in which predetermined constraints comprising worst-case computation time, period, minimum time between two consecutive exclusion relations, deadline, permitted range of offset constraints, precedence relations are satisfied. (Discussion on Dave's lack of ability to satisfy exclusion constraints is provided in item 11.1. above and is equally applicable to Dave and Dave2 and is hereby included here by reference.)

Claim 130 clearly distinguishes over Dave, Dave2, Lindsley, and Fong, or any possible combination thereof, since it is dependent on claim 115 which recites

"automatically generating a pre-run-time schedule comprising mapping from a set of periodic process executions to a sequence of time slots on one or more processor time axes, each of the time slots having a beginning time and an end time, reserving each one of the time slots for execution of one of the periodic processes, the positions of the end time and the beginning time of each of the time slots being such that execution of the periodic processes,

including satisfaction of predetermined constraints comprising

(1) worst-case computation times for periodic processes and asynchronous processes,

(2) period for periodic processes,

(3) minimum time between two consecutive requests for asynchronous processes,

(4) deadline for periodic processes and asynchronous processes,

(5) permitted range of offset constraints for periodic processes wherein a permitted range of offset of a periodic process comprising an interval that begins at a lower bound value and ends at an upper bound value which may

be equal to the lower bound value, the duration of the time interval between the beginning of the first period of said periodic process and time zero must be greater than or equal to said lower bound value and less than or equal to said upper bound value,

(6) precedence relations for periodic processes wherein each precedence relation being defined between a pair of processes comprising a first process and a second process, both said first process and said second process being periodic processes, said first process precedes said second process, execution of said second process only allowed to start after said first process has completed its execution,

(7) exclusion relations for periodic and asynchronous processes wherein each exclusion relation being defined between a pair of processes comprising a first process and a second process, said first process being either a periodic process or an asynchronous process and said second process being either a periodic process or an asynchronous process, said first process excludes said second process, no execution of said second process being allowed to occur between the time that said first process starts its execution and the time that said first process completes its computation,

can be completed between the beginning time and end time of respective time slots, including the step of converting one or more asynchronous processes into corresponding new periodic processes prior to the mapping step, and mapping new periodic processes to time slots in a manner similar to mapping of other periodic processes, such that said predetermined constraints will be satisfied".

Neither Dave, nor Dave2, nor Lindsley, nor Fong, nor any possible combination thereof, show the feature of *automatically generating a pre-run-time schedule including satisfaction of predetermined constraints comprising "exclusion relations for periodic and asynchronous processes wherein each exclusion relation being defined between a pair of processes comprising a first process and a second process, said first process being either a periodic process or an asynchronous*

process and said second process being either a periodic process or an asynchronous process, said first process excludes said second process, no execution of said second process being allowed to occur between the time that said first process starts its execution and the time that said first process completes its computation".
(Discussion on Dave's lack of this feature is provided in item 11.1. above and is equally applicable to Dave and Dave2, and is hereby included here by reference.)

Note that Lindsley performs synchronization only at run-time, NOT before run-time, so it is not capable of satisfying any constraints before run-time, which Applicant's invention, as defined by claim 130 would be capable of doing. Fong does not show any feature related to exclusion relations, consequently it does not show the feature above.

49.2.2. Neither Dave, nor Dave2, nor Lindsley, nor Fong, nor any possible combination thereof show the feature of permitted range of offset constraints for periodic processes

Claim 130 which is dependent on claim 115 clearly distinguishes over any combination of Dave, Dave2, Lindsley, and Fong since claim 115 recites

"including satisfaction of predetermined constraints comprising

...

(4) permitted range of offset constraints for periodic processes wherein a permitted range of offset of a periodic process comprising an interval that begins at a lower bound value and ends at an upper bound value which may be equal to the lower bound value, the duration of the time interval between the beginning of the first period of said periodic process and time zero must be greater than or equal to said lower bound value and less than or equal to said upper bound value, n,"

Dave, nor Dave2, nor Lindsley, nor Fong, nor any possible combination thereof show the feature of satisfying predetermined constraints comprising "*permitted range of offset*

constraints for periodic processes wherein a permitted range of offset of a periodic process comprising an interval that begins at a lower bound value and ends at an upper bound value which may be equal to the lower bound value, the duration of the time interval between the beginning of the first period of said periodic process and time zero must be greater than or equal to said lower bound value and less than or equal to said upper bound value, n,"

49.2.2. Neither Dave, nor Dave2, nor Lindsley, nor Fong, nor any possible combination thereof show the feature of determining the point that separates the initial part and the repeating part of the two-part pre-run-time schedule and how to construct the two-part pre-run-time schedule.

Claim 130 clearly distinguishes over any combination of Dave, Dave2, Lindsley, and Fong since claim 130 recites

> *"constructing a first schedule for executions of the periodic processes within an interval starting from zero and having length equal to maximum offset value plus a bounded number of times of the length of a least common multiple of the periodic process periods, conditions for determining feasibility requiring the existence of a point in said first schedule wherein starting from the latter point the schedule repeats in subschedule interval lengths equal to a least common multiple of lengths of the periodic process periods, timing of all executions of all periodic processes within a time interval having length equal to the length of the least common multiple of the periodic process periods being included in each said repeating subschedule interval, and including satisfaction of all predetermined constraints for all executions of all periodic processes within the subschedule interval starting from time zero and ending at said point plus the length of the least common multiple of the periodic process periods in said first schedule, and checking for the first occurrence of said point in said first schedule,*
>
> *(B)*
>
> *generating said feasible two-part pre-run-time-schedule by*

(1) using a subschedule interval starting from time zero and ending at said point in said first schedule as said initial part of said feasible two-part pre-run-time schedule, and

(2) using a subschedule interval starting from said point and ending at said point plus the length of the least common multiple of the periodic process periods in said first schedule as said repeating part of said feasible two-part pre-run-time schedule.

Dave, nor Dave2, nor Lindsley, nor Fong, nor any possible combination thereof show the feature of determining the point that separates the initial part and the repeating part of the two-part pre-run-time schedule and how to construct the two-part pre-run-time schedule.

49.3. The Suggested Combination Of Dave, Dave2, Lindsley, and Fong Would Not Be Physically Possible Or Operative.

There is plenty of unequivocal evidence that show that the suggested combination of Dave, Dave2, Lindsley, and Fong would not be physically possible or operative, here is just a few of them:

49.3.1 Lindsley and Fong describe methods which is totally void of any consideration of quantitative timing constraints.

Lindsley and Fong does not take into account:

(8) worst-case computation time values of asynchronous or periodic processes,

(9) deadline values of asynchronous or periodic processes,

(10) period values of periodic processes

(11) minimum time between two requests of asynchronous processes

(12) permitted range of offset values for periodic processes.

49.3.2. It is notoriously well-known, and common sense would also dictate that, if any single one of the above quantitative timing constraints is not taken into consideration, then there is absolutely no hope of satisfying the timing constraints.

49.3.3. The references of Dave and Dave2 do not contain any teaching, that suggests that their method could be physically combined with the teachings of Lindsley or Fong. Neither does the reference of Lindsley, or Fong contain any teaching, that suggests the teaching of Lindsley, or Fong could be physically combined with each other, or with the teachings of Dave and Dave2.

49.3.4. There is no evidence in the prior art that suggests that the references of Dave, Dave2, Lindsley, and Fong could be combined to produce an operative method.

49.3.5. Combining Dave, Dave2, Lindsley, and Fong will NOT produce an operative method that will cover all the features of claim 130 as Lindsley, and Fong do not concern themselves with timing.

49.3.6. As shown in item 49.1.1 above, Lindsley does not even consider periodic processes. This is also true for Fong.

49.3.7. As shown in item 49.1.1 above, the last O.A.'s citation of Lindsley is a misunderstood reference. The reference does not teach what the last O.A. relies upon it as supposedly teaching. The main task feature of "synchronous" is not identical to "periodic" as the last O.A. assumed.

49.3.8. The reference of Lindsley relies on the use of general semaphores. It is notoriously well known that general semaphores are not suitable for use in systems with hard deadlines and may prevent the satisfaction of hard deadline constraints altogether. Here is just one simple example: general semaphores are subject to deadlock and various forms of starvation, and just detecting deadlocks

alone is an NP-Hard problem, not to mention the total breakdown in any capability to meet any kind of timing constraints when a deadlock does occur. The entire specification of Lindsley completely ignores this problem. As to be expected, the references of Dave, Dave2, and Fong also completely ignores this problem.

49.3.9. Even if Dave and Dave2, are operative when functioning alone, and even if it is structurally possible to combine them with Fong, or Lindsley, the resulting method will be inoperative for the purpose of satisfying hard timing constraints at the very least because of the possibility of deadlock in Lindsley's method.

49.4. The Novel Features Of Claim 130 Produce New And Unexpected Results And Hence Are Unobvious And Patentable Over Any Possible Combination Of Dave, Dave 2, Lindsley, and Fong Under § 103

Claim 130 provides the following combination of features that have never before been provided simultaneously:

(1) Applicant's invention as defined by claim 130 provides the capability to enforce exclusion relations on pairs of processes that can be either (i) asynchronous processes that are not converted into new periodic processes and hence are not mapped into time slots in the pre-run-time schedule, or (ii) asynchronous processes that are converted into new periodic processes and hence are mapped into time slots in the pre-run-time schedule, or (iii) periodic processes that are mapped into time slots in the pre-run-time schedule, thus providing the capability to prevent errors caused by more than one process simultaneously accessing shared resources such as data in systems of one or more processors while also providing the capability to select precisely which pairs of process' executions

should not overlap in time when they access shared data thus maximizing the system's flexibility in meeting deadline constraints.
Neither Dave, nor Dave 2, nor Fong show this feature.

(2) Applicant's invention as defined by claim 130 simultaneously provides the capability to increase the flexibility of meeting deadline constraints when there is flexibility in assigning an offset value for a periodic process.
Neither Dave, nor Dave 2, nor Fong show this feature.

(3) Applicant's invention as defined by claim 130 simultaneously provides the capability to determining the point that separates the initial part and the repeating part of the two-part pre-run-time schedule and how to construct the two-part pre-run-time schedule that satisfies all specified constraints.
Neither Dave, nor Dave 2, nor Fong show this feature.

(3) Applicant's invention as defined by claim 130 provides the above combination of features, while providing the capability to handle processes that can be either (i) asynchronous processes that are not converted into new periodic processes and hence are not mapped into time slots in the pre-run-time schedule, or (ii) asynchronous processes that are converted into new periodic processes and hence are mapped into time slots in the pre-run-time schedule, or (iii) periodic processes that are mapped into time slots in the pre-run-time schedule, thus obtaining the advantages of pre-run-time scheduling including ability to use the information in the pre-run-time schedule to achieve greater predictability, ability to handle complex constraints, lower run-time overhead, and in general greatly increase the efficiency of scheduling; and the advantages of run-time scheduling including ability to handle asynchronous processes with very short deadlines that cannot be converted into periodic processes or will waste too much processor capacity if converted into periodic processes, while providing a guarantee that all the constraints, including hard deadlines, will be satisfied before run-time.
Neither Dave, nor Dave 2, nor Fong show this combination of features.

A. Applicant's invention achieves **unexpected results**: A system with all the above important features combined together, has never been realized before. The combination of results achieved by Applicant's invention are new and vastly superior compared to that of Dave, Dave2, Lindsley, and Fong or any combination thereof.

B. Applicant's invention is classified in a **crowded art** (a prior art patent cited by the O.A. states that, *"There is a vast amount of literature in the area of scheduling of soft and hard aperiodic tasks", Dave, col. 2, lines 47-48*); therefore, even a small step forward should be regarded as significant.

Applicant therefore submits that claim 130 is patentable under § 102 and § 103 and should be allowed, since they produce new and unexpected results over Dave, Dave2, Lindsley, and Fong or any combination thereof.

50. The last O.A. rejected dependent claim 111 on Dave, Dave2, (*Lindsley, see comments in previous item), and Fong. Claim 111 has been cancelled because Applicant considers it to be redundant over existing rewritten claims.

51. The Rejection Of Claims 67-68 Under 35 USC § 103 On Dave (US 6,178,542 B1), Dave2 (US 6,086,628), And Nilsen (US 6,438,573 B1) Is Overcome

52. The last O.A. rejected dependent claim 96 on Dave, Dave2, and Nilsen. Claim 96 has been rewritten as new dependent claim 146 to define patentably over Dave, Dave2, and Nilsen and any combination thereof.
Applicant submits that claim 146 is independently patentable over Dave, Dave2, and Nilsen and any combination therefore for the same reasons as given in item 15 above.

Additional Comments:
52.1. Nilsen merely mentions not allowing processes to exceed time slots, but does not offer any specific method on how to guarantee that processes will not exceed time slots in a context that is the same as Applicant's invention as defined in claim 146, that is, while guaranteeing that all timing constraints will be satisfied in the system. In fact, Nilsen

notion of not allowing processes to exceed time slots is completely foreign to Applicant's invention as defined in claim 146, because Nilsen may even suspend a task in order to guarantee that a task does not exceed a time slot. ("Make sure there is sufficient time in the current time slice to execute the complete atomic statement. ...If this condition cannot be satisfied at the current time, suspend the task." col. 17, lines 53-54). This can cause tasks to be delayed arbitrarily.

52.2. There is no suggestion, either from the references themselves, or prior art, that these references should be combined. Note that:

(a) Nilsen does NOT provide any guarantee, either before run-time, nor during run-time that all specified timing constraints, including deadline constraints, will be satisfied: Nilsen explicitly acknowledges that it is possible that the system's timing is not guaranteed:

(a1) The system may run behind schedule. ("Note that the real-time executive may need to revise the time budget dynamically (if, for example, the system finds itself running behind schedule.)," Fig. 13, lines -5 to -4.)

(a2) Time alarms may be postponed indefinitely. ("If the alarm was set before entering into the current atomic segment and the alarm time arrives while the application is still executing the body of the atomic segment, delivery of the alarm's exception is postponed until after the application leaves its atomic statement." col. 18, lines 41-45.)

(a3) Tasks can be suspended at any time. ("If this condition cannot be satisfied at the current time, suspend the task." col. 17, lines 53-54).

(b) Nilsen does not enforce exclusion constraints. ("It does not enforce mutual exclusion." col. 27, line 5-6).

52.3. Combining these references will result in an inoperative system, because of the above.

53. The Rejection Of Claim 71 Under 35 USC § 103 On Matsumoto (US5,448, 732) Is Overcome

54. The last O.A. rejected dependent claim 71 on Matsumoto. Claim 71 has been rewritten as new dependent claim 123 to define patentably over Matsumoto and any

combination thereof. Applicant requests reconsideration of this rejection, as now applicable to claim 123, for the following reasons:

Applicant respectfully disagrees with the last O.A.'s statement, "Referring to claim 71, Matsumoto teaches a method of determining whether each asynchronous process should or should not be converted into a new periodic process by calculating whether a ratio of processing capacity of the processor which is required to be reserved for new periodic processes, to processor capacity that is required for the asynchronous process if left unconverted, exceeds a predetermined threshold value. *("Each of [1], [2], and [3] is a condition for improving the theoretical effectiveness, and each of [4] and [5] is a condition for doing the same by determining "n" heuristically, or from experience. Depending on the application which is running, "n" is adjusted in order to improve efficiency. With respect to conditions [4] and [5], instead of the number of processes waiting for synchronization, the ratio of the number of processors in the group to the number of processors waiting for synchronization in the group is used," col. 6, lines 25-35*). As mentioned earlier, it is common knowledge in the art of task management and process synchronization that converting asynchronous processes to synchronous ones is merely synchronization. However, "Official Notice" is taken that both the concept and advantages of providing that the use of thresholds is well known and expected in the art. It would have been obvious to one of ordinary skill in the art at the time the invention was made to include thresholds to the existing method for the reason of increasing the control by being able to set limits or boundaries which determine one state over another." (Last O.A., page 22, item 53-54.)

Applicant respectfully disagrees with the above "Official Notice", and requests that documentary proof be provided, and the data be stated as specifically as possible, and the facts be supported, under M.P.E.P Section 2144.03 and 37 CFR 1.104(d)(2) for the "Office Notice" position that "the use of thresholds is well known and expected in the art. It would have been obvious to one of ordinary skill in the art at the time the invention was made to include thresholds to the existing method for the reason of increasing the

control by being able to set limits or boundaries which determine one state over another. In this specific case, synchronization would begin after the threshold is reached."

The reasons that Applicant disagrees with the above "Official Notice" are as follows:

1. Applicant submits that claim 123 is independently patentable over Matsumoto and any combination therefore.

2. Matsumoto fails to show any of the important features of claim 123.

3. The art of how to convert an asynchronous process to a new periodic process is not merely "synchronization" as suggested by the last O.A., it is one of the most important, yet least understood, and under-studied techniques in the field of real-time computing. Applicant's papers related to real-time computing have been reprinted in two IEEE Computer Society Tutorial collections and are also widely referenced in textbooks on real-time systems. Applicant is internationally well-known as an expert in real-time computing, and Applicant has taken a special interest in this particular technique for over 20 years, yet it had taken Applicant many, many years before Applicant realized and invented the technique shown by claim 123, hence Applicant can attest to the fact that the technique shown in claim 123 is far, far from obvious.

3. As can been seen in Fig. 26 of the drawings, and paragraph [0174], determining the ratio of processing capacity of the processor which is required to be reserved for new periodic processes, to processor capacity that is required for the asynchronous process if left unconverted, requires an elaborate procedure that is far from obvious. Hence Applicant is not surprised at all by the fact that no prior art has been found that meets the features shown in claim 123, because, to Applicant's knowledge, up to even today, no one has published a similar invention.

Conclusion

For all of the above reasons, Applicant submits that the drawings and claims are now in proper form and that the claims all define patentably over the prior art. Therefore

Applicant submits that this application is now in condition for allowance, which action Applicant respectfully solicits.

Conditional Request For Constructive Assistance

Applicants have amended the drawings and claims of this application so that they are proper, definite, and define novel structure which is also unobvious. If, for any reason this application is not believed to be in full condition for allowance, applicants respectfully request the constructive assistance and suggestions of the Examiner pursuant to M.P.E.P. § 2173.02 and § 707.07(j) in order that the undersigned can place this application in allowable condition as soon as possible and without the need for further proceedings.

Very respectfully,

Jia Xu, Applicant Pro Se

Enclosure A: Additional Drawings
Enclosure B: Clean Version of Entire Set of Pending Claims

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